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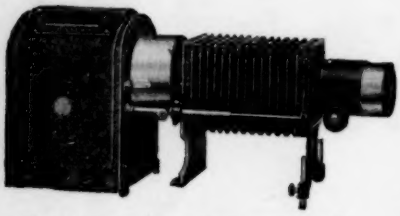

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVII, No. 4 APRIL, 1917 WHOLE No. 141

AN ARGUMENT FOR THE BETTER TEACHING OF MAMMALS IN ZOOLOGY[1].

BY HAROLD B. SHINN,

Carl Schurz High School, Chicago.

The development of the teaching of zoology has been marked by several important changes. At one time attention was directed almost exclusively toward classification; at another time toward microscopic work and histology; at another time attention focused upon the study of anatomy, and there still exist in the ranks of the teachers those who direct their attention to some one of these phases of study. In our recent review one teacher says that too much anatomy is called for; another in answering the same question says there is not enough anatomy. One teacher says that the study of the dog has little or no place in a high school zoology course; another says, "Hurrah! Let's all do it." The problem then presents itself: "How can we satisfy both extremes, or how can we draw them together to a middle ground."

In attacking the special problem of the teaching of mammals the very first thing is to influence the teacher's point of view, since the teacher is the first implement or obstacle in the work. We take it that modern educators are fairly agreed that education, or the making of a man out of somebody's boy, the making of a woman out of somebody's girl, can be attained by several different means, rather than by one only. The choice of these means might then depend upon which material comes closest to the personal life of the pupil or will enter most intimately into his later life. We claim that the mammals as a group are surpassed by none other in their appeal, in their economic value, and in the ease and efficiency of teaching the great problems of animal life and their various means of solution. It is

[1] A paper read before the Biology Section of the Conference of Accredited High Schools, at Urbana, Illinois, November, 1916.

up to the teacher to recognize these facts and to make his choice toward them by adaptation, migration, or extinction.

To illustrate may we cite first the subject of coloration. Melanism and albinism are well illustrated seasonally, while among the rabbits or other forms the use of recognition or flash colors in the tail or the back of the ears and the flash colors displayed by the errectile rump hairs of the deer are very illustrative material. The comparison of scales, feathers, and fur to show either origin or utility for heat conservation, evaporation or coloration is obvious. Evolution of the five-toed foot to the two- or one-toed hoof is just as easy. The development and care of the young, the change of a sebaceous gland to a milk gland is very comprehensible. The adaptation for winter is shown by the great migration southward of many northern forms and by the hibernation of those who cannot travel and cannot remain active. The dispersal of great groups from tropical birthplaces to temperate regions may be brought out.

Comparative anatomy is very easily taught to high school classes by the means of skeletal material, which is present or readily procured in any high school community. The skulls of dogs, cats, rabbits, muskrats, are common; many fore or hind legs of horses, sheep or cows can be secured, and occasionally ambitious pupils are very glad to undertake the preparation of entire skeletons. The great subject of dentition and its effects are readily understood, and perhaps such an outline as this may serve to crystallize the pupils' ideas:

Teeth—diet—edibility—habits—home—defense—disposition—death rate—birth rate.

We believe, further, that the domesticated animals among the mammals are of very prime importance in a zoology course. Why should we spend time upon the starfish when the history and habits of the common dog are at hand? Why undertake to classify the protozoa or the worms when a knowledge of the breeds of cattle, sheep, horses, and swine is so much more understandable, so much more immediate, and so much more valuable in the lumber room of the mind? Besides, many pupils are glad to undertake home projects during the work on the mammals, or even extending throughout the semester or year. Class excursions as field work can be undertaken to local dairies, stables, or kennels, or even across the snow-covered fields to the homes of the squirrels or the muskrats.

We hope in these brief statements to show that whatever

teacher may have changed his point of view in considering the mammals legitimate material will not have degraded himself nor sold his birthright, his college training, but rather will have brought a trained mind and scientific method into the largest and most profitable field of zoology teaching.

The second reason for giving the mammals more attention than they receive is that, in whatever locality the school may be, the community demands the study of mammals. The country and small town school herein direct their pupils toward a life that is not urban. The high school of a large city is here counteracting the tendency toward the education of the bookkeeper, stenographer, architect, or shop man. The appeal of the city is legitimate, but without some correcting influence will entirely dominate the appeal of the country.

The third reason for undertaking the study of mammals more extensively is that the capacity of the pupils is fit. A great many of those things which we learned in college and later undertook to teach our classes were beyond their comprehension. Even as it is true that some of the greatest things in the world are simple things, so it is true here that the simplicity of mammals in no way detracts from the greatness of their problems. The very simplicity of these problems as adapted to the high school age only serves to impress upon the pupil the vastness of nature, the greatness of life, and the profoundness of its problems.

The fourth reason is that of appeal. We maintain that education of the people is for the people, that rather than discourage pupils with abstruse problems in embryology, anatomy, and nomenclature it should be our purpose to arouse their interests in school work and to make them want to stay in school because it is an interesting place, rather than to drive them out to paltry jobs. It does not matter what mammalian material we use for laboratory work, the appeal is there. We may use guinea pigs, white rats, rabbits; we may ask Johnny Jones to bring his dog to school; we may run the Babcock test for butter-fat for somebody's cow; we may have some of the girls save cream, churn, and spread their butter on soda crackers, which are then passed through the class; we may all go outside and study the conformation of somebody's pony or horse. We may recall the dependence of man upon his domesticated animals all through the past ages and from this make a short step to the history of mankind, both prehistoric and historic, noting the great waves of migration, so similar to those of other animals, which have resulted in the

dispersal and settlement of definite races in certain regions. In fact it would not be entirely disgraceful for the zoology teacher to bring out a little of local history. What Indian tribes formerly inhabited the locality and when did settlement occur? Or the appeal may be made more personal by working from the question of stock-breeding to that of human-breeding or eugenics.

You will recall that when Linnaeus undertook his work at Upsala the first time, he was deemed a heretic by his colleagues, but that his work became so popular or so attractive that local jealousies compelled his resignation. We do not believe that appealing to the pupil's interest is beneath the dignity of the teacher. To be personal, zoology in our school is entirely elective and competes with all the other sciences above the first year and the percentage of failure in the zoology classes ranges from sixteen to twenty-five, yet there are more pupils taking zoology than any other science in the school above the first year. Parents have personally thanked us for arousing the interests of some indifferent boy or girl and helping to keep him or her in school.

The fifth obstacle in the way of using mammalian material in the classroom is that of equipment. The average school has little or no illustrated material other than an occasional book. Even at its best the school library furnishes talks about animals rather than the animals themselves, though an occasional reading from the writings of Burroughs, Sharpe, or Stone & Cram, may serve a very valuable purpose. Material more illustrative is that of picture post cards, Mumford plates, or, best, photographs, scrap books and albums made up by the pupils themselves, of local or personal interest. Government and state reports furnish material for individual thesis work.

Horns and skulls can often be secured from the local slaughter house, some to be hung as trophies on the wall. Dissections can be made by individuals in the class; pelts can be secured, small forms stuffed, and perhaps various forms of traps shown. Large mammals, alive, can be studied outside, and the dog or those smaller used in the room. At Gary, a racoon and several other pets are kept in cages in the school yard; in fact, report has it that a small menagerie is kept up by the zoology classes.

In conclusion we would venture the assertion that the obstacles to teaching mammals in high school are largely factitious and we put forth a strong plea for their more widespread use and more careful treatment.

A FIRST COURSE IN ZOOLOGY IN THE HIGH SCHOOL—CONTENT AND ORGANIZATION[1].

By Jerome Isenbarger,
Nicholas Senn High School, Chicago, Ill.

There are three important factors which must be considered in the development of any well-regulated course in high school zoology. These are (1) the teacher, (2) the laboratory, and (3) field work. There is a fourth which looms far above any of these and which should control and determine all other factors, namely, the pupil. I hold that first, foremost, and all of the time the needs, likes, and dislikes of the pupil must be kept in mind while considering any problem which enters into the shaping of a suitable course in zoology for high school pupils.

The teacher of zoology should be an enthusiastic believer in his subject. He should be guided in his selection of material for a successful course by a purpose similar to that expressed by Dr. Hodge in a formula as: "Learning those things that are best worth knowing, to the end of doing those things that make life most worth living." He should be thoroughly cognizant of the fact that zoology should meet a need in the high school curriculum which can be met by no other subject. In other words, it should have aims and purposes distinctly its own.

To my mind, the teacher should conduct rather than "hear" the pupils in their recitations, and he should be a participator with them in their laboratory work. He should bridge over the gaps by amplifying and suggesting at every turn.

The study of animal forms must appeal to the pupil as real. The pupil must be impressed with the fact that the nature which he is studying is near at hand and not something which is foreign to his everyday life. The natural love for things living must be fostered. Since the youth at high school age is a utilitarian, he should be led to see the interrelations of plant and animal life and the relation of animals to human welfare.

I am of the opinion that if our aims for the study of animals are to be realized, the principles which I have briefly outlined must determine the subject matter of the high school course. It will naturally vary according to the individual preparation of the teacher and to peculiar local conditions, but in any event the course must rest upon some substantial foundation and it must lead somewhere.

[1]Read before the Biology Section of the Central Association of Science and Mathematics Teachers, at University of Chicago, December 2, 1916.

It is not my purpose to attempt to outline a course of study. It will be within the scope of this paper to give some of the main features of the work which we have found suited to the needs of the boys and girls in the Nicholas Senn High School, together with some additional comments.

The course during the fall semester begins with the study of insects. In selecting forms for study no attention is paid to taxonomic order. Such forms are selected as can be studied in succession alive in the laboratory and in the field. As a rule we find it best to begin with the Lepidoptera. Caterpillars of the Polyphemus and Cecropia moths are still easily obtained during the first and second weeks of September, and pupae can also be found. The larvae are fed upon willow leaves during the study and until they pupate. The process of cocoon spinning is watched with great interest. As it is impossible to study the adult forms of these insects alive at this time, the pupils are given prepared specimens in Riker mounts for this study. Other Lepidopterous insects whose life history the pupils are permitted to observe in th laboratory are black swallowtail, monarch, and mourning cloak butterflies. The moth cocoons which were spun in the laboratory are kept in the laboratory until March or April when the pupils can see the moths emerge.

The locust beetle has been found a convenient form of beetle to study alive. Placed in a cotton-stoppered tube with a sprig of goldenrod it forms an excellent study in protective coloration. I have not been able to secure living grubs for this study, so use preserved grubs of the June beetle. Beef and fish scraps exposed in an open quart jar among the weeds in a vacant lot will attract scavenger beetles and will afford an opportunity of studying a most interesting life history.

When the study of the housefly is begun, material which has previously been prepared will show larvae, pupae, and adult flies. Each pupil is furnished a cotton-stoppered tube containing fully developed maggots. By the next day these will have formed pupae, and left in the same tube will develop into the adult form. It is an impressive experiment to secure larvae from a garbage can which has been only partially covered and left for four or five days.

After a study of Diptera, each pupil makes a sanitary survey of his neighborhood, locating on a map places where conditions are such that flies or mosquitoes may breed, also shops where food is sold with their grade in per cent as to cleanliness, also

houses where there have been cases of transmissible disease for which flies or mosquitoes might have been responsible. The pupil embodies the results of his investigation in a report in which he includes his conclusion with regard to the relation between the sanitary condition and the health of the community. While the maps and reports have not been uniformly good, yet I have been very much pleased with the manner in which this problem has been attacked. It furnishes an excellent lesson in civic responsibility, and tends to develop a civic pride which is highly desirable.

The list of insect studies is not complete, but those given serve to illustrate in general the manner in which representatives of eight or nine orders are taken up. In every case r presentatives of the order are studied alive in the field or in the laboratory, or in both field and laboratory.

As final work in the study of insects, tables are made showing lists of beneficial insects, insects which transmit disease, and insects injurious to farm, orchard, and garden crops. Various methods of controlling the different types of insect pests are studied, and the pupils are taught how to make use of the services furnished by national and state departments of entomology. A much-needed addition to our equipment is a barrel spray pump which might be loaned to pupils to aid in the fight against scale insects.

The length of time given to the study of insects is ten weeks. Thus they are made the main feature of the work of the fall semester. The work on spiders is introduced by placing female garden spiders in the cage with the flies while the latter are still plentiful. Habits of web and cocoon spinning are readily observed as well as those of feeding. Crayfish are easily kept alive in shallow water in the laboratory for study following that of insects and spiders. The points emphasized with the crustacea are relations to environment, parasitism, evolution, and geological history.

The studies of Protozoa, sponges, coelenterates, worms, and mollusks serve to develop in a logical manner the subjects of the different metabolic processes and reproduction and development.

The vertebrates are left for the work of the second semester. The two groups which should receive the emphasis in the spring term are the birds and the mammals. The lower forms should be taken up as subordinate. Very little if any dissection should

be attempted, and classification should deal largely with the larger groups.

As the fall season is particularly suited for the study of insects, so the spring is particularly suited for the study of the birds. The summer and fall migrations are extended over so long a period that they are seldom noticed except by the experienced bird student. Bird habits, bird homes, and bird protection are best studied when the birds are with us in greatest numbers during the spring migrations.

The bird work begins on March 1 when the classes begin to make the annual bird calendar. A few lessons are given previous to this date to introduce the work and to pave the way for an interest which will develop lively competition.

Each pupil is given a number of blank forms showing a picture of a bird with blank spaces for a list of characters, locality, number of birds seen, date, and name of the observer. When a pupil sees a bird for the first time during the season, he fills into the picture the characteristic markings and into the blank spaces the description which would serve to identify the bird.

The pupil either identifies his bird on the spot with the aid of a color key, or he may take the slips which he has filled out into the laboratory and make use of the books of the library in making his identifications. In either case the identification is checked up by the instructor before it is counted to the pupil's credit.

As the birds are reported for the first time, the bird calendar is made up. Opposite the name of the bird is the locality, date, and the name of the pupil who first reported it. Many of the pupils work independently, doing their field work alone or in groups, but field trips by classes are necessary in order that those who are more dependent may receive some help and to guard against the temptation to use dishonest methods. These class trips are taken during laboratory periods, in the morning before school, in the evening after school, or on Saturday morning. During the last spring term, one of our teachers and a considerable number of her pupils were sufficiently enthusiastic to begin the morning trips at 4 o'clock in order to study the birds at the time of their greatest activity.

A certain number of identifications are required of each pupil, but most of the pupils do not stop with the required number but enter into a lively contest for the greatest number of birds correctly reported. The average highest number identified by

any one pupil during the past three years was 148, and the average of the highest number reported by all members of the classes was 174.

During the period of bird study, the birds are considered from every angle in their relation to man's well-being. The value of the birds as destroyers of injurious forms of animal and plant life, and the importance of protective measures, are studied by by means of class discussions, library work, pictures, and stereopticon slides. The bird is considered as a neighbor and a friend whose importance is sufficient to demand respect.

Mammal study is a phase of the zoology work which merits more prominence in the course than is usually accorded it. The work may center in domestic animals and pets, but in cities with living wild animals in captivity and with many books on mammals available the work should be quite extensive.

Living mammals such as guinea pigs and rabbits should be kept in the laboratory and such other living animals as may be available should be used, but here much use should be made also of books.

The course in zoology which I have had in mind while preparing this paper covers the work of a full year. It could hardly be modified to form a successful half-year's course. Experience in schools of various grades in different sections of the country in half-year courses of zoology and botany has convinced me that a half-year course in either subject cannot be satisfactory. Insect study, to be effective, must come in the fall, while the bird and mammal work must come in the spring—and there is material a-plenty for the time intervening.

I have not differentiated between the course suitable for the pupil who is to enter college and that suitable for the pupil whose school training is to end with that of the high school. A college instructor told me that he preferred pupils for his classes who have not had high school zoology. Students who have had a rehashed college course in the high school are inclined to overestimate their real ability, and as a result look upon the freshman college work as a review. After all, the test of the value of a course is not information stored up, but power developed. I am inclined to think that the zoological training that will best fit for life will also best fit for college. If the high school work is suited to the needs of high school pupils, we need have no worry over the question of duplication in the first year of college.

The real measure of a high school course in zoology is the amount of life, figurative and literal, that is put into it. Pupils must see and handle the living animals in the laboratory, and observe and study them in the field. We should permit minute dissections and involved taxonomic studies to go back to the college whence they came. Let us give our pupil the knowledge and training which he craves and needs, that which will add in the greatest degree to his fullness of life as an individual and to his worth as a citizen in the community.

THE AMARYLLIS.

By Genevieve Monsch,
Froebel School, Gary, Ind.

In the numerous lists of plants for indoor decoration or for schoolroom use, there is one which is seldom included and which I think should never be omitted, no matter how small the list. This is the amaryllis.

About two years ago, I was given an amaryllis in the zenith of its glory by the man who has charge of our school grounds. Since that time it has never failed to send up at least one tall handsome stalk of most beautiful deep pink blossoms in the middle of the winter, and again about midsummer. An accident to the heating plant soon after Christmas (January 19, 1916) killed off practically all of our most valuable conservatory plants, and our amaryllis was reduced to a mere mass of limp, lifeless leaves. After some deliberation, we decided to save out of our frozen stock most of those plants that had such underground parts as bulbs (like the hyacinth, tulips, and amaryllis), or rootstocks (as ferns), or corms (as cyclamen, etc.), in spite of the fact that we knew that it would take so much time and energy to get them back to normal that they were really scarcely deserving of so much space in our small and always crowded conservatory.

However, the amaryllis more than repaid us for our pains. In not less than two days, one of the children espied a new "leaf" already an inch above the ground. This new "leaf" turned out to be a big flower bud which shot upward with such surprising rapidity that even the most unobserving children could "see it" grow from day to day. Many of the pupils became interested in measuring it each morning before school. This is what they found:

Friday,	Jan. 21, 1916	2.1
Monday,	Jan. 24, 1916	?
Tuesday,	Jan. 25, 1916	8.6
Wednesday,	Jan. 26, 1916	10.0
Thursday,	Jan. 27, 1916	?
Friday,	Jan. 28, 1916	13.5
Monday,	Jan. 31, 1916	25.0
Tuesday,	Feb. 1, 1916	30.0
Wednesday,	Feb. 2, 1916	34.0
Thursday,	Feb. 3, 1916	38.5
Friday,	Feb. 4, 1916	42.4
Monday,	Feb. 7, 1916	55.5
Tuesday,	Feb. 8, 1916	58.0
Wednesday,	Feb. 9, 1916	60.0
Thursday,	Feb. 10, 1916	?
Friday,	Feb. 11, 1916	?
Monday,	Feb. 14, 1916	67.2
Thursday,	Feb. 17, 1916	67.3—Maximum

Do you wonder with such figures as these that the children could really "see" the plant growing?

In the meantime, of course, the plant had produced a new supply of strong, healthy foliage leaves which grew with almost as much energy as the flower stalk. (All of the measurements that we made of the growth of the foliage leaves were accidentally erased from the board before we even had a chance to compare them with our other measurements. Moreover, a second large flower bud was shooting upward before the first bud had fully opened, and numerous new bulbs developing from all sides of the old bulb underneath the ground were indicated by new clumps of foliage leaves pushing up here and there above the surface of the soil.

Since such live interest had been centered upon this plant, it was quite natural to extend our work upon it. In previous years, we have always sacrificed its blossoms for classroom analysis. The flower is especially valuable for this purpose, not only because of the simplicity of its structure, but also because of the large size of all of its parts. Even the fourth grade children can understand this flower, and they usually appreciate the meaning of bract, perianth, stamens, pollen-grains, stigma, ovary, etc., long before the day set for the final sacrifice of the flowers. What is still better, the children have come to know the functions of all these parts. "Tearing the flower to pieces" serves in this case only to give them a little more intimate acquaintance with its parts, especially the details of the ovary, and leads them into a systematic method of analyzing the more complex and the smaller flower forms. It is perhaps unfortunate for the teacher that this flower does not possess characteristic

calyx and corolla, especially since we might find it convenient to use as a type form with little children. However, its perianth shows such definite outer and inner whorls that after all we can easily teach "calyx and corolla" and at the same time show the force of the word "perianth."

This year, instead of analyzing our amaryllis flowers, we decided to use them for experiments in pollination, fertilization, reproduction, etc. And I would like to say right here that, while I have tried to use various other flowers from time to time during the winter months for this work, I have never been so successful as with the amaryllis. I consider this by far the most valuable service that the amaryllis renders to education in elementary botany.

The first flower stalk produced two flowers. In order to prevent promiscuous pollination, we cut the stigma out of the first of these, then with our fingers we transferred its pollen to the stigma of the second flower. From day to day we watched the fading of the two flowers and noted especially the rapid development of the ovary in the second or pollinated flower and its shriveling in the first or unpollinated one. In less than a month from the day of pollination, the pollinated flower had matured and formed the amaryllis fruit, and was discharging quite a number of black winged seeds, while the ovary of its friend beside it was a dried-up, lifeless-looking specimen. Except for the fact that we had kept the whole plant away from every breath of air, this unpollinated flower would perhaps long before have been shed as a useless ornament. The black seeds were distributed among a class of about thirty eighth-grade pupils, who eagerly took them home to grow. After one week, three girls reported that theirs were growing (between the toothpicks which marked the exact position of the seed), while the rest of the class were still watching. We also found one of the seeds, which had accidentally fallen on the soil in the flowerpot, beginning to sprout after about two weeks.

In the second stalk there were three flowers, and we pollinated all of these. Two of these have matured their seeds, while the third one is less than half the size of the other two. We have been wondering if this small plant would have strength and energy enough to take care of so many ovaries and seeds at the same time. It does seem as if the last one is to be a dwarf, to say the least.

I cannot begin to tell in this article what an active interest

was kept up during the interval of about ten weeks from the time of the freezing of the aerial parts to the maturing of four fruits, and how many interesting scientific problems were opened up for discussion in an informal way. Several classes day after day remembered the amaryllis immediately upon coming into the room, and never failed to examine it at once, and then they often besieged the teacher with questions. While I purposely avoided using the amaryllis for any set formal class work, I must give this plant credit above all things for having illustrated by its own magnificent growth a number of otherwise incomprehensible scientific principles. It also furnished numerous occasions for bringing in allied forms of plant life.

In conclusion, I shall present a brief outline of a few topics which were the direct outcome of having kept this one small pot of amaryllis in a conspicuous part of the schoolroom or an interval of about ten of the "deadest" weeks of every botany year. While the amaryllis was not disturbed or used at any time for class work, it was constantly suggesting new problems and causing us to turn aside from our set tasks into new paths opened up by one or another of the children themselves. The amaryllis was continually shedding its interest upon our class work, and in consequence was increasing and keeping alive its own inherent interest and exerting a vitalizing influence upon much of our daily work.

Here are some of the topics aroused and discussed because of this plant:

Bulbs (onion used as illustration).
Bulb propagation (Chinese sacred lilies in bowls of water used as illustration).
Value of underground parts in surviving or escaping frost (herbaceous perennials).
Value of food storage (rapid renewal of aerial parts).
Development of buds.
Flower clusters.
Structure and functions of the flower and its parts.
Problems of pollination (cross-pollination, self-pollination, insect, wind, indoor-pollination).
Lack of pollination (no fruit develops).
The meaning of fertilization.
Maturing of the ovary into fruit.
Maturing of ovules into seeds.
Structure of fruit.
Distribution of seeds (winged seeds in amaryllis).
Characteristics of monocotyledons: (a) parallel-veined leaves; (b) one seed leaf (showing when amaryllis seed begins development); (c) parts of a flower in threes or sixes.

SOME PERSONAL EXPERIENCES WITH GENERAL SCIENCE.

By J. C. Gould,
Glasgow High School, Glasgow, Mont.

My first abrupt introduction to general science did not engender any warmth of welcome within me. Its reception was about as enthusiastic as that of a lump of ice into the refrigerator, with the temperature several degrees lower. First impressions, however, are not always to be relied upon. As I was at one time being introduced around as a newcomer to a boarding house in a strange town, there was a young woman among the crowd whose aspect was so stern and forbidding and far from cordial that my heart sank at the prospect of facing her at the table there for nine months. Just how that misconception arose, to spread such consternation, I could not later understand. That same young woman is now my wife.

I had not been aware that such a course of study even existed, when, the day before school began, the superintendent announced to me that a class in general science would be included in my schedule for the semester. The notification did not even allow time before the course began to read over the text and see what it was all about. It could not be truthfully said that I was in any sense pleased, nor that the new class appeared in the light of an opportunity.

Apart from my unpreparedness, or the abruptness of acquaintance, the general science course did not appear to me as being a desirable addition to the curriculum. It seemed an attempt to give a smattering of scientific knowledge in an easy way—just enough to make the pupil think he knew it all, when he had really only had his mental back scratched without anything getting under the hide.

There were quite a number of young people in the country neighborhood where my youth was spent, who acquired a college education by taking a three months' course in a business college in a near-by city. With not even a complete rural school education as a foundation, they could not by any possibility have received in that length of time any commercial training of practical value in the subjects they took. But to prepare for some office job, or to help run the farm affairs in a more businesslike way, was far from their object in going

They went chiefly to be able to say with affected nonchalance in the course of their converastion, "When I was to college ——." There was a certain self-satisfaction and complacence in the knowledge that they were educated, polished, refined. They could not distinguish a pronoun from a metaphor, and would have been at a loss to decide whether the kinetic theory might not be some form of brain storm induced by hard study—but they had been "to college."

I judged that the general science course was to be about the same sort of a vehicle to a shallow veneer of scientific instruction that the business college was to a "college" education. Could J. G. Coulter's paper on "A Four-Year Science Course for High Schools" have fallen into my hands at that time, I would have given at least three cheers and two tigers for each sentiment on general science expressed therein.

There is no need to say that, with the teacher in such a mental attitude, my first class in general science was not a brilliant success. The net result of the course, as far as any practical gain in scientific information or the acquiring of scientific habits of thinking by the pupils was concerned, was in the region of absolute zero.

There were other contributing factors to the failure of the course. General science was offered as a half-year course; and the majority of the class enrolled just to seize upon any easy half credit that presented itself to be laid up against a possible future scholastic rainy day, and not because they had any special inclination toward science. In the opinion of the class, general science was merely a side issue, and not really a part of their high school course. Most of them scraped along through the semester, and finally barely got out of the course exactly what they went into it for—their credit.

Presenting general science as a half-year subject involved influences fatal to its success other than the attitude of the pupils toward the course. The daily program had been practically fixed, and it was not considered advisable to disrupt the schedule to give the general science class the luxury of an occasional double period for laboratory work. The text we used had no accompanying laboratory manual, and my work was so heavy that my time for study was insufficient to permit the evolution of a laboratory course. Even could I have done so, the amount of material in the text precluded any possibility of setting aside any recitation periods for laboratory

work, if we were to cover ever so hastily and superficially the subject matter of the text. As a consequence, the class had to get what laboratory experience it received vicariously, in the form of classroom demonstrations by the instructor.

With everything working against it in this way, there is not much to be wondered at in the failure of my first general science venture.

The next year I moved to a new location. During the summer, in talking over the general situation and my special work with the new superintendent, I learned that he had decided to try out general science. I did my best to dissuade him, but to no avail. He was willing to avoid, if possible, the faults that had spelled failure in my previous attempt, but was determined to make the experiment.

Since I had to teach it anyway, I decided to make the most of it, and began a systematic study of the general science situation. In the first place, the text selected by the superintendent was a new one; and upon comparing it with the text of the previous year, the course began to look more desirable. There was a better choice of subject matter, and written up in such a readable fashion that I found myself interested as I read it, even though there was no information in it with which I was not already familiar. The method of attack was more natural, and better adapted to the average ninth grade mind and to the environment of the average pupil.

Besides studying the textbooks, I read every article written on the general science situation upon which I could lay my hands, to find out what the men who knew most about it thought. Before reading many articles, I began to do some thinking for myself; and the wheels of thought had not creaked through many revolutions until they had ground out the realization that all my science teaching had been aimless. Each year each class went through its particular text, and that was about as far as any aim or policy went as far as I was concerned.

I had endeavored to make my science classes sufficiently entertaining so that the pupils would not dread them and consider their teacher dry and uninteresting; and I had discovered that the way to do this was to present as many everyday applications of scientific principles as possible. But the motive in doing this was entirely selfish, and involved no consideration of the needs of the pupils.

In my efforts to avoid lifelessness and lack of interest in the classroom, I had inadvertently done in a haphazard fashion some degree of that which I have since systematically and consciously striven for. Awakened by the general science articles, it became my fixed aim in all my science teaching to make it vital, in order that the students might put the knowledge acquired to practical, everyday use; and I tried to emphasize those phases of the different subjects that had a direct bearing on local conditions. Probably my most valuable experience with general science was this indirect influence it had in motivating all my science teaching.

My second general science class could be rather contrasted than compared with the first. My own attitude had changed greatly. While as yet not convinced as to the efficacy and desirability of such a course, I was willing to give it a fair trial, and withhold my judgment until the evidence was all in. We had early decided to make it a full-year course, with the result that there was plenty of time for adequate laboratory work, and it was not necessary to strain, and hurry, and skim over in a mad rush to get through. The students who registered for general science did not base their choice on the idea of a half-year subject for a little easy credit on the side, but took it because they wanted it for what they would learn. And, finally, for the laboratory manual to accompany the text had not yet been issued, I had during the summer outlined a laboratory course for the class. In that way, the chief elements that, in my opinion, had caused the failure of the first trial, were eliminated in this second experiment with general science.

The results were beyond anything I had ever hoped for, and so far ahead of my actual expectations that the distance would have to be measured in terms of some large unit. The class met at nine, the first period; but it was nothing unusual to find members of the class waiting for me to arrive, at about eight, to get into the laboratory to see the results of some experiment started the day before. The class period was usually so short that they forgot to eye the clock, unless in apprehension lest there would be no time to have some special question answered.

It all seemed to be as wonderful and absorbing to them as a fairy story, yet with the added touch of reality. They had been living in a world full of wonders and mysteries and

miracles, and had not even known it. They had seen plants grow, but thought, if they thought at all, that it was done after Topsy's fashion of just growing, when here it was in reality a most amazing process. They had heard of disease germs, but the bacteria, for instance, that soured the milk were all unknown. Every day they gained some new piece of knowledge that was more fascinating, if possible, than that of the day before. It was by far the easiest, most interested, and most interesting class I had ever taught.

One surprising thing in regard to the general science classes has been their ability to grasp certain of the more theoretical phases of science, as, for example, the kinetic theory. They seem to possess the ability to visualize and make things real in a much greater degree, or at least with less effort, than the older students who meet the concept for the first time in physics. The first-year students appear to have more vivid imaginations.

My experience has not yet been extensive enough to warrant any definite or final conclusion. The superior ease of the ninth grader to visualize may have been simply an example of the difference between individual classes. Yet it has recurred enough times to quite convince me that it will prove true every time. The high school freshman is entering upon a new existence educationally, and things make a greater impression than upon the more sophisticated junior or senior. He is nearer the fairy story age, and life seems more "sort of mysterious like." He is not ashamed to be enthusiastic, and show it. He is not afraid to let his imagination loose. At this break in his educational life, he is in a psychological condition to meet the strange new concepts, and let his imagination out to keep pace with them. Later on in the high school course, he is not mentally capable of being stirred to such a degree by new ideas. And no study the high school student pursues offers such a store of brand-new ideas and information as does general science.

One of my first grounds for distrust of general science was that it would give the student a smattering of scientific knowledge along with a smug, self-satisfied complacency that would feel no need of any further study of science. That fear was evidently quite groundless, as practically every general science student here who has continued in school has registered for more science.

In the matter of getting pra tical results in the application of their new knowledge to the problems of life and of play by the pupils, general science has been far more productive than the other sciences. Homes have been made more sanitary, food better chosen and better cooked, sickness avoided, and a much greater interest taken in home life and duties as a result of the information derived from the general science course.

One boy tested a sample of the milk of each of the cows on their farm, and found to his surprise that the most profitable cow was not the one who gave the most milk. Such an object lesson could not but make the care of the cows more interesting, and less a chore. One girl's study of bacteria resulted in a much cleaner dairy farm, with the milk dishes properly scalded and sunned. One girl in the class, as a special topic, reported on a U. S. bulletin on septic tanks. As a result of that investigation, her ranch home will soon have its private sewage system. One of the boys lives near an intermittent stream which has dug a hole near his home that usually contains water. Stimulated by things he learned in general science, his spare time is spent largely by this hole, where he has a fleet of ingeniously constructed battleships, with old clockworks for engines, lookouts made from umbrella frames, and guns that shoot. Another boy constructed a small aeroplane.

I might multiply such instances, but there is no need. In my own experience, I have passed from opposition to the enthusiastic support of general science. If the subject matter is properly chosen and presented, it is one of the most vital courses in the curriculum.

INCREASING USE OF ALUMINUM IN MANUFACTURE OF AUTOMOBILES.

Metallic aluminum now competes strongly with other sheet metals and with wood in the manufacture of automobile bodies, according to reports by the United States Geological Survey, Department of the Interior. This position in the market has been attained through improvement in foundry methods for casting metallic aluminum and increase in knowledge of suitable alloys. Large sections of aluminum castings are now used in making touring cars and the inclosed bodies of certain other motor cars, a use which was not practicable ten years ago. Cast aluminum is also used for making automobile dashes. Bodies made of it are lighter than those made of other sheet metal and have a rigid surface that will not dent easily when handled. They are also safer in case of accident. The aluminum surface retains paint well, and the increased rigidity makes the car more durable.

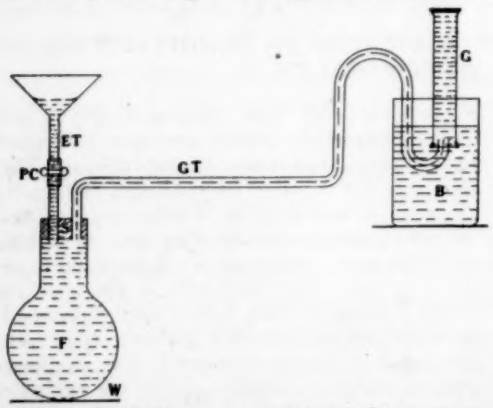
THE PERCENTAGE OF OXYGEN IN AIR.

By Erle M. Billings,
West High School, Rochester, N. Y.

The method of determining the percentage of oxygen in the normal atmosphere is familiar to everyone. The simple elementary experiment of taking a known volume of air at a known temperature and pressure and inserting into this volume a small piece of phosphorus is the one to which reference is made. By careful manipulations, pupils obtain very good results by this method. In biology, this experiment is used in its crudest form. Here a large bell jar is placed in a trough of water. A cork stopper has a piece of phosphorus the size of a pea on it. This is ignited and the bell jar is lowered quickly into the water, covering the burning phosphorus. In chemistry, a graduated glass tube is used, and corrections are made for differences in levels, aqueous tension, etc., thus making an admirable problem in gas measuring.

In discussing this experiment, instructors refer to the fact that the air is a mixture, and consequently the different components may be separated from it by many different methods. During the discussion, it is generally remarked that air is dissolved in water, and that it is this which supports marine life and also gives taste to the water used for drinking purposes.

The amount of air (or any mixture of gases) dissolved in water depends upon solubility and the partial pressure which each component exerts in this mixture. Temperature, of course, is a factor. With the aid of the apparatus shown in the following diagram, the amount of air dissolved in water may be shown and its percentage of oxygen determined:



G.—50 cc. glass graduate.
B.—200 cc. beaker.
G. T.—Glass tube at each end with rubber connecting tube.
F.—Liter flask.
E. T.—Entering tube with funnel.
P. C.—Pinchcock on rubber connection.
W.—Wire gauze.
S.—Two-hole rubber stopper.

The whole system is filled with water which has been poured

from one dish to another several times so as to be sure it has dissolved much air for that temperature. This filling is best done as follows: Fill the graduate first and invert it into the beaker of water. Now pour the prepared water through the funnel connected to the entering tube (E. T.) until water flows into the beaker (B) through the tube (G. T.). Be sure the exit of G. T. is not beneath the mouth of the graduate when the filling is done, as enclosed air will enter the graduate. Having completely filled the system, place a flame beneath the flask (F) and heat gently at first and later strongly. This heating will cause the water to part with its dissolved air, the latter rising to the top of the flask and entering the tube (G. T.). As the water warms, the bubbles of gas slowly work their way through G. T. until the water begins to boil, when gas escapes quite rapidly into the graduate. It is very easy to tell when all the air is driven off as the steam will tend to escape through G. T., but will instantly be condensed by the water in the beaker (B). When all the gas is driven off, open the pinchcock (P. C.) and take the exit of G. T. from beneath the mouth of the graduate (G). This, in brief, explains the filling and working of the apparatus.

When the gas has cooled to room temperature, a reading will show that from 20 to 25 cc. of gas have been driven off from a liter of water.

Should the teacher desire to prove what percentage of this is oxygen, no difficulty is encountered. All one is obliged to do is to insert a piece of phosphorus attached to a small copper wire and proceed as in the classic experiment in elementary chemistry. Very good results will be obtained. If the water taken be at 10° Centigrade, then the correct percentage of oxygen in the dissolved air is 34.47; at 20° C., 34.03 per cent; at 25° C., 33.82 per cent; at 30° C., 33.60 per cent.[1]

This simple and interesting experiment can be used in biology, physics, physical geography and chemistry. In biology, as a demonstration, it shows that air is dissolved in water and at the same time that the dissolved air is much richer in oxygen than atmospheric air. Also, it bears out the statement that the air is a mixture to a nicety. In physical geography, it can be utilized to the same extent as in biology. In physics (as ordinarily thought of), it finds its least application—simply illustrating the fact that air (gases) dissolves in water (liquids). But in chemistry, again as a demonstration, it is extremely valuable. Dalton's

[1] Landolt-Bornstein, *Physikalisch-chemische Tabellen*, 1905, page 605.

law, the solubility of a gas depends upon its nature, the nature of the solvent, the temperature, and the pressure (Henry's law), air being a mixture, are some of the points to which it has a bearing.

It is the hope of the writer that this experiment may be of use to some other teacher or that it may suggest a better way for securing the same results. The writer would also like to express his sincere thanks to Mr. Robert Morrison for making readings and computations in the working out of this experiment.

MEASUREMENT OF THE HORIZONTAL COMPONENT OF THE EARTH'S MAGNETIC FIELD BY A SIMPLIFIED ABSOLUTE METHOD.

By Lindley Pyle,

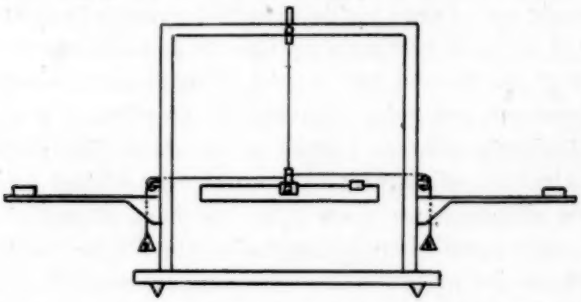
Associate Professor of Physics, Washington University, St. Louis, Mo.

In the absolute determination of the horizontal component, H, of the earth's magnetic field, it is customary at some stage to make use of the formula, $T = 2\pi\sqrt{I/MH}$, where the symbols have the usual significance. In elementary courses, the student may not be familiar with the derivation of this formula. The simplified method to be described has been given a thorough trial in teaching practice, and is recommended as being easily grasped and quickly performed, average deviations from the mean of independent determinations of H being less than two per cent.

Choose a piece of cast steel, approximately 60 centimeters in length and about four square centimeters in cross section, and magnetize it symmetrically to a high intensity. (Such a specimen should exhibit a pole strength of about 900 absolute units with a distance between poles of about 50 centimeters, yielding a magnetic moment, M, of approximately 45,000 c. g. s. units.) Locate the poles of the magnet by laying it in an east-west position upon a table, then holding a compass box in contact with it, the axes of the compass needle and the bar magnet being in the same horizontal plane. Take as the location of the poles those positions where the axis of the needle stands at right angles to the axis of the magnet.

With a piece of floss, free of torsion, suspend the magnet by a clamp gripped at a point midway between its poles (see Figure). Prevent the magnet from dipping by use of a non-magnetic coun-

terpoise. The clamp is equipped with a cylindrical extension about half a centimeter in diameter, around which is wrapped a silk thread, the ends of which are equipped with weight pans. Let the thread extend out horizontally over two delicately mounted pulleys. Distribute masses equally between the two pans, until the turning moment applied to the suspended system holds the magnet at right angles to the magnetic meridian.



With the magnet held at right angles to the meridian, place a compass in the extension of its axis at such a point that the compass needle is deflected 45°. This point is easiest found as the point where the needle will deflect 90° when the suspended magnet is rotated by hand through 180°, in a horizontal plane. Evidently, it is the point where the magnetic intensity, F, due to the magnet, is numerically equal to the horizontal component, H, of the earth's field—although at right angles thereto. Let the point be D centimeters distant from the center of the suspended magnet.

Let L represent the distance from the center of the magnet to its poles, m.

Then $F = H = m(1/(D-L)^2 - 1/(D+L)^2) = 4mLD/(D^2-L^2)^2$.

Let d represent the diameter of the clamp extension plus a single thickness of the silk cord.

Let w represent the total mass of pans and contents.

Then $2\ mHL = wgd/2$,

Whence $H = wgDd/H(D^2-L^2)^2$,

$$H = \sqrt{wgDd/(D^2-L^2)}.$$

The acceleration of free fall, g, may be obtained by observation of the length and period of a simple pendulum, the student being already familiar with the derivation of the formula, $T = 2\pi\sqrt{l/g}$.

It is desirable to place the compass first on the east and then on the west, taking the mean value of D as the true value. It is then evident that four distinct values of H are really involved in the equations, namely, the values at points distant D and L centimeters east and west from the center of the suspended magnet. The value finally calculated may be taken as representing very closely the true value of H at the center of the suspended magnet.

A sample set of data yields $w = 24.7$ grams; D = 91.2 centimeters; $d = 0.585$ centimeters; L = 26.2 centimeters; $g = 980$ centimeters per second per second. Calculation indicates H = 0.149 dynes per unit pole. Incidentally, $m = 907$ c. g. s. units.

One distinctly valuable feature of the above simplified method is that after all adjustments are made, the student sees before him at a single glance the whole experimental procedure as a case of static equilibrium—a balance of turning moments applied to the suspended magnet and to the compass needle, respectively.

CLASS ROOM SAYINGS

All the answers are genuine and are quoted exactly.

The following statements were taken from examination papers:

"We breathe one breath and give out another, making two."

"They (tadpoles) have small round mouths which are sucking and by means of *this fact* they hold themselves attached."

"To prove this (mutation) DeVries experimented with primroses and Ancon sheep."

"The stability of protozoa might be accounted for by the staidness of the ectosarc."

"Alcohol is often used where a strict temperance man has a very doubtful case of phmonia (pneumonia)."

"To see if bacteria will develop itself."

"The preliminary (pulmonary) artery."

"Some people say alcohol is a stipulant."

"Pheumagated" (fumigated).

"In civilized nations women breathe from the trachea."

"A nerve travels at the rate of 170 feet per second."

"Unknown 'B' was and could be made alkaline by neutralizing by an antidote which gives a bright color when the mixture is alkaline."

"The heart is covered with a membrain or a protectorate."

"Two other functions of leaves are breathing and execration of water."

"Nerve fibres are sometimes classed as telegraph wires."

"Roothairs are to make soiled water sweet" (osmotic action of roots).

"The skin gives off moisture when we are not ostensibly perspiring."

"Cigars irregulate the heart."

"Cholera is not in all places (mostly seaports) but may be *fatal for a few days.*"

OLD AND NEW METHODS OF TEACHING CHEMISTRY IN HIGH SCHOOLS.

By Oliver C. Short,

Trenton, N. J., High School.

The reason that there is a question of new methods of teaching chemistry in the high schools is due to the fact that, within the past few years, there has come a public demand for more practical education. It is the same movement that has put in the high school curriculum mechanical drawing and shop work, domestic science and art; that has vitalized teaching of mathematics in many places, introducing carpenter's arithmetic, shop geometry, etc., and in this clamor for more practical education, the sciences have come in for their share of criticism. My present attitude toward teaching of chemistry has been a matter of conversion.

Pardon a personal reference. I was born and received my primary, secondary and undergraduate education south of the Mason and Dixon line and, after graduation, taught for three years in the South. Those of you who are familiar with the conditions in the South a few years ago will bear me out in the statement that whenever a pupil entered a secondary school of the standing of our public high schools, he had a well-defined intention of continuing his education in some institution of higher education. In the graduating class of the last school I taught in the South, there was not a boy who did not have plans well made to enter college, and in the same state fifty per cent of the graduates of the high schools of last June, boys and girls, are now in colleges of scholastic standing—Dickinson, Western Maryland, Washington, Maryland Agriculture, Delaware, Swarthmore, Haverford, etc. With this early training and experience, I had my mind well made up as to what should constitute a high school course in chemistry, so that when I was engaged to teach chemistry in a high school in northern Pennsylvania, and the superintendent wrote me to prepare an outline for chemistry in the high school, I briefly, but with conviction, said that I considered that if we prepared boys and girls of the high school to enter college, that we were doing the best for them that could be done toward preparing them for life and all that could be expected of us as high school teachers, and suggested the use of some of the common texts, MacPherson and Henderson, Brownlee, etc. The super-

intendent replied that he thought I should think about the matter a little, and we would talk it over when I came on to begin the work. When I took charge of the class that fall, a class in which there was not a girl who had plans beyond the homes of the community and but one boy who, after an indefinite period in one of the local drug stores, had plans to take a course in pharmacy somewhere, I began to realize that my preconceived notions would not lead to the best results, so began at once to plan for a course in chemistry that would be more vital to those boys and girls. It was with a great deal of pleasure to me that I was allowed the privilege, four years ago, of outlining and putting into operation a course which involved these ideas in the Trenton High School.

I think my position might be made clear if I cite a few instances that were definite experiences at the time I was teaching the usual college preparatory chemistry. You are familiar with the usual textbook treatment of carbon monoxide, for example. We are given its method of preparation from oxalic acid, the proper use of sulphuric acid in the process, and are told that it possesses certain physical properties, among them that it is lighter than air and poisonous, and, under its chemical properties, the dogmatic statement is made that it burns with a pale blue flame and is a powerful reducing agent. To establish this last fact, reference is made to its importance in the iron-reducing industry. I taught that subject, as I have no doubt many of you have, without arousing one particle of interest or enthusiasm on the part of the pupil; but when I shifted the viewpoint, and told the pupils that carbon monoxide was prepared whenever carbon burned in a limited supply of oxygen, and that the blue tongues of flame seen shooting through fresh lumps of coal thrown on a hot bed of coals in a range or furnace were flames from burning carbon monoxide, and, too, that the carbon monoxide was prepared when the coal in the range or furnace was burning slowly, that is, when the lower draft was shut off, and would, unless given an outlet through the stovepipe, pass out into the house and perhaps poison the occupants, I had no trouble in arousing interest and enthusiasm on the part of the pupils, and at the same time in driving home the essential chemical facts regarding this particular compound. You are also familiar with the textbook treatment of the reaction between a ferric compound and potassium ferrocyanide forming ferric ferrocyanide, and when this is treated with an alkali a reddish brown substance is formed,

called ferric hydroxide, which would filter out. This again was a subject that was as so much foreign material to the pupils, but I found that when I told them that the ferric ferrocyanide was Prussian blue, a compound once extensively used for clothes' bluing, and that if, while the bluing was in the clothes, they should be put into a strong soap solution or washing soda, that deposits of iron rust would be made on the clothes, then the subject became vital to the members of the class. At that point, I carried the matter a bit further, and told them that the reason why iron rust was not removed from clothes by plain washing was because it is insoluble, but if it were treated with hydrochloric acid, then a new compound is formed, called ferric chloride, which is soluble and easily washed out. These illustrations may be a criticism of the textbook, I do not doubt but that they are, for in our usual college preparatory chemistry courses, the textbook determines the course.

In the laboratory, the instances are as many as in the classroom. I will cite one. You recall the experiment that is usually performed in the high school chemical laboratories with water glass which results in, what we usually call, sea sand. A few years ago, I had a girl in a chemistry class who performed this experiment with accuracy, carefulness and skill. At the end of the experiment, she turned to me and asked what she should do with what she had prepared, and I told her to throw it away. With a look of disappointment, she made this significant remark, "All that work for nothing." I may be a traitor to my calling, but frankly I did not attempt to correct (if "correct" is the proper word to use) that girl's opinion of that experiment, because I realized that she saw absolutely nothing in the chemical processes involved that she could connect with any experience in life. There was nothing there to connect the known with the unknown.

In Trenton, the course is given to girls only. The first year, we had forty-three in the course; the second year, sixty-two, and the third, the present year, seventy-two. It is an optional course for girls in the Scientific Department in the high school. They come into the course after having had biology or physics in their junior year, no chemistry with the exception of chemistry related to these other sciences. Oxygen, carbon dioxide, carbohydrates, fats, proteids, etc., are familiar substances to the girls from the biology. The heat transformation in changing physical

state, electrolysis, distillation, etc., are familiar subjects to those coming from the physics. We call the course, household chemistry; but if by household chemistry is understood the household chemistry of Miss Dodd, our course is not household chemistry. This text is too elementary. Nor is it Vulte and Goodell's *Household Chemistry*; too few subjects are treated there. Nor is it Kahenberg and Hart's; the first part of their book is adaptable to our work, the second part is not. Nor is it Professor Snell's; his work in many respects is not suitable for our course either. It is rather all of these and many more. We have no textbook in the hands of the pupils. Subject matter is given to them in semi-lecture form, classroom demonstrations, board work, etc., on which they take notes, do supplementary reading, prepare reports, answer frequent oral and written quizzes, and finally record the notes in a permanent notebook. Our object is to relate the subject to the daily experiences of the pupil, yet teach chemistry.

How do we do this? In the beginning of the course, we lay a chemical foundation on the usual chemical terms, physical and chemical changes, physical mixtures, chemical compounds, elements, all of which are illustrated, talked about, examples cited, definitions established. Attention is given to simple formulas, equations, the principle of definite and multiple proportions, atoms, molecules, their relative weights, chemical affinity, analysis, synthesis, decomposition, direct union, etc. Following this introduction, we require each pupil to take an outline of how to study the elements and how to study the compounds. Of the elements, we require the name, symbol, atomic weight, occurrence, preparation, physical properties, chemical properties and uses. Of the compounds, we require the name (common and chemical), formula, occurrence, preparation, physical properties, chemical properties and uses. Instructions are given that no element will be studied and no compound without filling in the outline with appropriate facts of the substances. Beginning then, we study oxygen and hydrogen as separate elements, following them with the subject of water. With the knowledge that they have now gained of the process of oxidation, we study the disposal of sewage and garbage, that is, household waste. Air comes next, with the outline study of the elements and compounds that are found in the air. Acids, bases and salts receive next consideration and, during the study of these, litmus paper is distributed to the class with instructions to take it home and make tests on materials used at home and bring to class lists of

their findings. Fuels come next, separated into solids, liquids and gases, under which a study is made of the range, gas burner, use of mantles, reading of meters, etc. Carbon as an element is taken at this point. Carbon dioxide and monoxide are studied as before pointed out, at which point the pupils learn how to adjust drafts on the range and furnace, and for what reason. Matches are studied, and under these phosphorus as an element. This subject is followed by cleansing agents, bleaches, antiseptics, disinfectants, these with the study of fabrics, under which heads such elements and compounds as chlorine, iodine, sulphur dioxide, bleaching powder, sodium hydroxide, etc., etc., are studied by use of the outline previously mentioned. Metals such as are found in the home, with special reference to their durability and use as composition of household utensils, are next studied. We devote our last half year to the study of foods. Thus, in familiar groups, the subject matter is presented in a vital way, and each new chemical receives attention at the appropriate place and to the extent its importance demands.

I have gone thus fully into the explanation of the course for a few lessons in order to answer a criticism, namely, that our pupils are not getting chemistry, and, secondly, how we aim to make the course practical to the everyday household. Professor Snell says, "The principle kept constantly in mind (of teacher and pupil) is to introduce the applications of chemistry to household affairs as early and as often as possible." I would like to add, "At the same time bring these applications in on a sound chemical basis." For example, hydrogen peroxide is a compound familiar to practically the whole class. As soon as the pupil learns that it is of an unstable nature and what it loses when it decomposes, with a previous knowledge of nascent oxygen, he has no trouble in knowing its use, why it is sold in amber bottles, and why we are instructed to keep it in a cool, dark place. Phosphorus: When a pupil learns that it has a very low kindling temperature and is a poison, he has no difficulty in knowing its application in the manufacture of matches and rat poison, and why it has been wise to discontinue its use in matches. I have found this method of teaching chemistry a "drawing out process" that I have never been able to obtain in teaching any other subject or teaching chemistry in the old way.

I have been asked the question if this course is not rather a general science course. My answer is, no, if by general science is meant the general science we are familiar with in the first

year of high school. Our course is more special. I have also been asked if it is not rather a course in domestic science. My answer again is, no. I would like to have pupils who have had a course in domestic science, but the course is the chemistry of the domestic science rather than domestic science itself, as commonly understood in public school courses. I would object to the course being given below the senior year in high school unless the time could be extended and the last half of the Junior year devoted to elementary chemistry.

Of course, the pupils are the fruits of our labors. Some will give a good account, others not so good, and some poor, of what this or any other course means to them. Some will not be able to talk intelligently on a laboratory experiment just finished, but none fail to see a reason for doing the experiment or studying the subject matter in class.

Perhaps a question has arisen in the minds of some of you about our graduates. Some of them go out into ordinary life and take no further educational training. Some go to training school. A few of the graduates enter college, and we hope to have more who enter college. Can these pupils pass the college entrance examination? I doubt it as the examinations are now set, but if they are allowed to enter college, they will keep pace with the other pupils in the college chemistry, or I miss my aim. Personally, I hope for a growth in number of such courses, and also for a more general recognition of such courses by the colleges, but until we get that or if we never do, we still have that large majority for whom, I will agree, we would do a good service if we prepared them to pass college entrance examinations, but a much greater, if we put them into touch with life processes. Thus, in conclusion, I wish to emphasize that I believe that a teacher who faces a class in science, the usual majority of whom go out in ordinary life, is missing a splendid opportunity for service, when he fails to connect definitely and vitally that science with the daily life and experiences of the pupil.

SHORT STORIES OF GREAT INVENTIONS.

By A L. Jordan

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(Continued from March.)

18. The Electric Furnace. Electric heating dates from the time of Volta and Davy, but the first experiment in electrometallurgy was the production of cementation steel by William Pepys (Eng.) about 1815. It was not until 1853 that attempts at electric furnaces were made, one in England by J. H. Johnson, another in France by Pichou. These were commercial failures. The first furnace attracting public attention was that of William Siemens in 1878, where the molten metal formed one electrode. The Cowles Brothers (Eng.) in 1884 and 1885 finally succeeded in the production of aluminum alloys, and aluminum itself was made (by a combination of the electrolytic and heating effects) by Hall in America and Heroult in France, in 1886 or 1887. Elihu Thomson patented a resistance furnace in 1886, Borchers (Ger.) produced a successful one in 1891, and DeLaval made an attempt in 1892. In 1892 also, Moissan, using an arc furnace and employing the marvelous nonconducting properties of quicklime, produced calcium carbide; while Acheson, using a resistance furnace, discovered the well-known abrasive carborundum. This was followed by the commercial production of calcium carbide (whence the making of acetylene gas) by Willson in 1895.

A new type, the induction furnace, useful where iron free from carbon is desired, was invented by Ferranti in Italy and Colby in America in 1897. Work along similar lines was done by Stassano (It.), 1898; Kjellin (Swedish), 1900; Hjorth (Swedish), 1904; Frick (Eng.), 1904; and Girod (Fr.), about 1905.

Electric welding, forging, etc., are very nearly related to work with furnaces. The first electric welding of which we have record is that of a bundle of iron wires by Joule in 1856. The use of the arc for cutting and welding (where the material is one electrode) dates back to 1881 when De Meretens did "lead burning" with it. A more general use was made by the Russian Bernardos about 1901. The deflected-arc process began with Wederman in 1874, who used an air blast; the use of a magnet for deflecting the arc was by Zerener about 1881. A very novel and spectacular method is that of the "water-pail forge," introduced by LaGrange and Hoho (Belgians) in 1892.

Lastly, one of the most important welding processes is that of Elihu Thomson (1889), employing the heat from the resistance (at the points of contact) to the heavy current from the secondary of a special step-down transformer.

19. THE WHEATSTONE BRIDGE, the great fundamental measuring instrument for all ordinary resistances, was brought to public attention by Wheatstone in 1845, but this was, as Wheatstone himself states, invented by Christie in 1833.

We are more or less familiar with its variations in construction (slide wire, "Post Office," dial decade, etc.), but some neglect the importance of a sensitive galvanometer and an accurate resistance box. The latter is the invention of Werner Siemens, but the "rheostat" is credited to Wheatstone.

The story of the search for a suitable resistance material (before manganin, platinoid, etc., were selected) is interesting, as is also that of the "aging" of the wire, the difficulty of determining its exact temperature at the time of measurement, and other refinements, as the use of the ice bath or motor-stirred oil immersion. The names of Carey Foster, Lord Kelvin, and Varley should also be put down for their share in the development of the bridge.

20. GALVANOMETERS. The "frog's leg" experiment of about 1780 furnished the first means of detecting an electric current, but the electromagnetic type began with Oersted's great discovery (Denmark) in 1819. That the magnetic needle could be used to detect very small currents followed immediately upon Schweigger's discovery (Germany, 1822) of the use of a coil of many turns of wire, and such "moving-needle" instruments have reached marvelous perfection and have taken many shapes.

The "moving-coil" instruments, now becoming widely used, are frequently called "D'Arsonval galvanometers;" but D'Arsonval (1882) merely put into commercial form the instrument used by Sturgeon (one of the inventors of the electromagnet) in 1836. Lord Kelvin's submarine cable "siphon recorder" is of this variety.

Most of the other prominent types, as the solenoid and plunger, the ballistic, etc., are electromagnetic in action, with the exception of a few of the "hot-wire" or expansion type.

21. ELECTROMAGNETISM began with Oersted in 1819, and his work was at once added to by Ampere and by Arago (in France), who in 1820 discovered that iron filings cling to a copper wire

bearing current, that steel could be magnetized, etc.

In 1825 Sturgeon (Eng.) constructed the first practical electromagnet, and in 1829 Joseph Henry, working independently, improved it so much that its commercial development may be dated from that time. This definite combination of a coil of wire with soft iron (only in a few cases, as the telephone receiver, the polarized relay, etc., is the core of steel) became a necessary part of dynamos, motors, bells, telegraph sounders and relays, galvanometers and most measuring instruments, annunciators, switches, and other remote control apparatus.

22. The Reversibility of the Dynamo. The fact is that every dynamo can be made to run as a motor. Faraday's discovery (1831), that a conductor moved in a magnetic field has a current induced in it, was the reverse of his experiment (1821) where a magnet rotated about a wire carrying current; but Lenz (1838) seems to have been the first to recognize that fact. The real reversibility of an actual dynamo was shown by Jacobi in 1850. This did not become generally known, and it was independently discovered by Pacinotti (1864) and by Rowland in America. Another story has it that it was stumbled upon at the Vienna Exposition of 1873 by a workman who connected two leads (not knowing them to be alive) to a dynamo, which at once ran as a motor. By some, the discovery is credited to Fontaine & Gramme at this same date.

23. The Transformer was really discovered by Faraday in 1831, but it did not become of industrial value until 1882, when Gaulard & Gibbs began to make transformers in England. In this long period, men had not been idle, however, work having been done by C. F. Varley, Jablochkoff, Ferranti, Zipernowski, and others.

The first transformer in the United States is claimed to have been that of William Stanley at Great Barrington, Mass., in 1885. At about the same time, the far-seeing George Westinghouse acquired the Gaulard & Gibbs rights for America and began their manufacture here.

The columns of the electrical journals now note casually the construction of transformers of 5800 K. V. A. capacity (5,800,000 watts at unity power-factor) to operate at 150,000 volts. These high voltage transformers, representing marvelous engineering skill in methods of cooling, good insulation, bracing of coils against possible distorsion, overcoming magnetic leakage, avoiding "aging" of the iron or steel core, etc., have efficiencies

of over ninety-eight per cent. And how difficult it is for the observer to grasp what is going on within the smooth shell of one of these almost silent monsters!

The gradual increase in the voltages used is paralleled by the improvement in insulators, culminating in the suspension type. This kind handles any increase in voltage by simply adding more units to the "string," the limit being the point at which "corona" makes its appearance on the wire.

24. THE WIRELESS TELEPHONE. A hissing condition of the electric arc was noticed by De La Rive (Swiss) in 1849, a musical arc by Lecher in 1888, another form by our own Elihu Thomson in 1892, and one by Blondel in 1893. As it was recognized that the arc was the seat of high-frequency oscillating or regularly pulsating currents, inventors were stimulated in the hope of its use for telephonic transmission (using the wireless ether waves). While one patent (Marconi, 1895) is recorded of an effort to use a high-frequency alternator for wireless transmission, the experiments of most of the workers were along the line of musical arcs.

Simon (1898) is regarded as the real inventor of the "singing arc," and his work was followed by that of Blondel, Collins, and Duddell in 1900, Szczepanik in 1901, Fessenden and Poulsen (the latter using hydrogen gas and cooled metal electrodes) in 1902, Ruhmer, Pierce, and Majorana in 1904, Fessenden, Ruhmer, and M'Carty (a San Francisco boy) in 1906. Lee de Forest in 1907 transmitted music a few blocks.

When well adjusted, the perfected apparatus gives marvelous results, more awe-inspiring than those of the ordinary telephone; but it is subject to many interferences, requires careful adjustment, and at present can compare with wireless telegraphy for long distance work, only on rare occasions.

25. OHM'S LAW. The law now known to the world as Ohm's law was discovered away back in 1800 by Cavendish in England. But that austere and self-effacing scientist published not one word of many discoveries, this one included, and it remained unknown until Ohm's experimental paper came out in 1826. (His book containing the theoretical deduction came out in the following year.) He was at this time a hard-worked teacher in the gymnasium at Cologne, and lacked appliances and good books; but with the skill obtained when a boy from his father, a locksmith, he constructed most of the apparatus (including the thermopile used as a source of current) for his investigations.

He was ambitious to become a professor in a university, but the tardiness of recognition should be noted; he taught in Berlin for six years, in Nurnberg for thirteen years, and finally in 1849 was appointed extraordinary professor at the University of Munich. He became full professor in 1852, and enjoyed the fruition of his life's hopes for two years only, dying in 1854.

26. The Voltaic Cell. Galvani (of Bologna) discovered in 1780 that frogs' legs would twitch when they were touched to two different (connected) metals. His theory of "animal electricity" was disputed by Volta (of Pavia) who had been working with static electricity for some time (he had invented the electrophorous in 1775). It is recorded that Volta had noticed the peculiar "taste" produced by holding a gold and a silver coin in the mouth in about 1790 (anticipated in this by Johan Sulzer, in Germany); and his experiments on the chemical nature of the source of these electric currents culminated in the construction of the voltaic pile (zinc, copper, cloth moistened with vinegar) and the "crown of cups" (simple cells in series) in 1800.

From that date to the present, the efforts of inventors to overcome polarization, to produce low internal resistance or high elecromotive force with economy of materials, to develop cells for continuous or for intermittent use, or for standard electromotive force, resulted in numberless varieties of cells.

Among the best known are the following: Grove, Bunsen (or Poggendorff), Grenet, Daniell (and gravity), Fuller, Leclanche (and "dry"), silver chloride, Edison-Lalande, Clark and Weston.

It is interesting to compare the progress made in the world's knowledge of electricity for almost two thousand years with that made in the one hundred years following Volta's capital discovery.

27. The Storage Cell. It is stated that Gautherot, one year after the publication of Volta's discovery, found that platinum or silver electrodes would give a current of short duration after the electrolysis of water. In 1803 Ritter noted the same thing (using gold wires), and constructed the first secondary battery, plates of gold and discs of cloth moistened with ammonia.

Some knowledge of the subject was contributed by Volta himself, by Davy and by Marianini, and in 1837 Schoenbein used "suboxide of lead." Work with oxides of lead was done by Grove, Wheatstone, Siemens, and Faraday, and in 1842 Grove attracted attention to his "gas battery" of fifty cells, which was powerful enough to produce an arc light.

The commercial development of the storage cell dates from 1860 in the work of Plantè who used the lead, lead oxide, sulphuric acid combination. Others have tried lead-copper, lead-zinc, and copper-iron (alkaline zincate solution), but the only important improvement in the lead cell since the time of Plantè was that of "pasting" (which now means shortening the time of "forming" the plates by having pellets of lead salts forced into holes in the plates, sometimes by a hydraulic press). This was made a commercial success by Faure in 1879, but the process had been invented by Metzger previously. It was invented independently in this country, and the U. S. courts gave the decision for priority to Brush.

The only radical change since then has been the development (about 1905) of the nickel-iron cell by Edison. (The solids are nickel oxide and iron, the liquid is a solution of caustic potash containing a little lithium hydrate.) Its advantages are that it is much lighter, will stand a high charging rate, and is not injured by lying idle when discharged. One disadvantage is its high cost; another, for some kinds of work, is that its e. m. f. discharge curve is not so "flat" as that of the lead cell.

28. ROENTGEN OR X-RAYS. This series of stories of great inventions may well close with that of the most mysterious of them all. How commonplace now is the news that some friend has had "an X-ray photograph," or that a bullet can be located exactly by the fluoroscope with a stereoscopic attachment.

The discovery of these wonderful rays is a recent one (1895), and most of us remember the sensation created by the publication of Roentgen's modest paper, in which he referred to them as X-rays, but which the world rightly calls by his name.

His discovery followed the invention of the Crookes tube and some experiments by Lenard and Hittorf. The fact that an exhausted bulb having electrodes connected to the secondary of an induction coil has a peculiar set of rays from its cathode was known; Roentgen found that the other electrode, the anode, was the source of a "new kind of light" which would penetrate substances opaque to ordinary light, exciting fluorescence in substances like barium platinocyanide and affecting a sensitive plate.

Edison constructed the useful fluoroscope in 1896 (also claimed for Professor Salvioni) which at once made it possible for the surgeon to locate any body denser than human flesh by "seeing" its shadow on the screen of the instrument.

RECENT TENDENCIES IN THE TEACHING OF ELEMENTARY APPLIED MATHEMATICS.

By J. R. Young,
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(*Concluded from March.*)

The private commercial schools seldom offer any mathematics other than general and commercial arithmetic. In the public secondary schools, the commercial departments sometimes add the subjects of algebra and geometry. Arithmetic for the secondary schools is highly developed and relatively closely applied. As was indicated quite early in this discussion, the first arithmetics were practical manuals intended primarily as a means of preparation for business life. This department has consequently had the advantage of an early start. Much oral drill is given. The problems are, in the main, real business problems. Interest tables are about the only ones used, and an effort is made to present the problems as they would occur in the business world. Some use is made of the laboratory method, and a number of the schools employ adding machines in working the longer problems. Textbooks are commonly used, and there are a number of good commercial arithmetics on the market. The *Complete Business Arithmetic*, by George H. Van Tuyl, teacher of business arithmetic in the High School of Commerce in New York City, may be taken as typical of the best commercial arithmetics. This book, which contains 412 pages, places emphasis upon the development of principles rather than set rules, provides problems which have a definite informational value, and makes extensive use of calculation tables. Many problems are provided for mental drill. Common and decimal fractions are combined, as in business. About one-half of the problems deal with business affairs, most of them being given in the last half of the book. Short methods and the checking of results are emphasized.

The report of Committee No. VI states that the algebra in the commercial high schools is largely vocational, that the students study the applications of the subject, that it is correlated with arithmetic and science, and also to a certain extent with commercial geography and economics.[11] It would have been of special interest if the committee could have secured a statement of the applications of algebra to business which have been developed in the High Schools of Commerce. In the commercial departments of the regular high schools, there is no separate algebra for commercial students.

[11] *Bulletin, Bureau of Education, 1912, No. 4*, pp. 24–25.

The work of the Lane Technical High School of Chicago may be taken as fairly typical of the work done by the polytechnic high schools, though the work in the Lane High School is more closely applied than in many of the schools of this class because of the part-time system and the close articulation with the industries. This institution offers both two-year and four-year courses. The courses in mathematics are as follows:[12]

In Two-Year Courses in Patternmaking, Machine-Shop Work, Carpentry, and Electricity:

Year.	Course.	Time.
I.	Algebra or shop mathematics	Both semesters, 5 hours a week
II.	Geometry	Both semesters, 5 hours a week

In Two-Year Course in Printing:

I.	Business arithmetic	Both semesters, 5 hours a week
II.	No mathematics.	

In Mechanical Drawing:

I.	Shop mathematics	Both semesters, 5 hours a week
II.	Geometry	Both semesters, 5 hours a week

In Four-Year Technical Course:

I.	Algebra	Both semesters, 5 hours a week
II.	Geometry	Both semesters, 5 hours a week
III.	Adv. algebra (1st sem.), solid geom. (2nd sem.)	5 hours a week
IV.	Trigonometry (optional)	Second semester, 5 hours a week

In Four-Year Architectural Course:

I.	Shop mathematics or algebra	Both semesters, 5 hours a week
II.	Geometry	Both semesters, 5 hours a week
III.	Solid geometry	Both semesters, 5 hours a week
IV.	Trigonometry	Second semester, 5 hours a week

In Four-Year General Trades:

I.	Algebra	Both semesters, 5 hours a week
II.	Geometry	Both semesters, 5 hours a week
III.	Solid geometry	Both semesters, 5 hours a week
IV.	Trigonometry (optional)	Both semesters, 5 hours a week

In the above courses, it is the intention to cover the mathematics usually given in the regular high schools.

In th Apprentice Schools.—There are two apprentice schools —carpentry and plumbing—in the Lane High School. The purpose of these schools is to supplement the training which the apprentices get in their daily work at the trades. The carpenter apprentice school is open during the three months of slack work, January, February, and March. Plumbers' and gasfitters' apprentices attend the plumber apprentice school from 8 to 11:30 o'clock once a week. Carpenters' apprentices

[12] *Lane Technical School Yearbook*, 1914.

attend during the third and fourth years of their apprenticeship, while the plumbe s' apprentices are accepted at the school when their respective unions send them, and they leave the school whenever the unions feel that hey are qualified to take the journeymen's examination.

The work in mathematics in the Carpenter Apprentice School is thus described:

"*Mathematics.*—The carpenter's rule; the linear table; addition, subtraction, etc., with whole numbers; fractional parts of an inch; drawing of lines to scale. Mathematical reason back of test of plane surface by means of the square; areas of straight-line figures. Use of the "scale"; the decimal system; taking off board feet; comparison with cubic measure. Finding lengths of common, hip, and valley rafters, braces, etc.; the rise and run forming legs, rafters or brace the hypotenuse, of right triangles; square root. Obtaining cuts in stair stringer, plate and ridge cuts of common rafters, etc.; similar figures; proportion. Use of steel square in obtaining cuts for stair winders and bevels of any slant; use of tangent table; reduction of decimal to common fractions. Estimating from plans; lists of material; allowance for waste; cost of labor; reasonable profit. Strength of material; solution of formulas."[13]

The following outline of the work in mathematics in the Plumber Apprentice School is given:

First Year:

(*a*) Study and measurement of lines developing the linear table and the four fundamental processes with numbers.
(*b*) Inverse process, using common fractions, especially parts of an inch.
(*c*) Thorough study of processes with whole numbers and common fractions.
(*d*) Deriving of simple formulas for areas and perimeters.
(*e*) Mensuration—simple figures.

Second Year:

(*a*) Measurements, using tenths, hundredths, thousandths, etc., of an inch, giving decimal form.
(*b*) Operations with decimals.
(*c*) Square root in right triangles; evaluate π where possible.
(*d*) Ratios of lines—grade—percentage—proportion.
(*e*) Angles—names—relations—offset measurements.
(*f*) Business arithmetic—trade discounts.

Third Year:

(*a*) Further application of formulas.
(*b*) Problems involving flow of water in pipes, filling and emptying of tanks, volumes of liquids, etc.
(*c*) Estimating from plans.

[13] *Lane Technical School Yearbook*, 1914, p. 86.

In the trade schools, the work in mathematics is somewhat more narrow and specialized than in the technical high schools, though not so limited as in the apprentice schools. The point of view of the teachers of mathematics in the trade schools is probably fairly well represented by the following statements:[14] "The work throughout the course is of a most practical nature, the sort of mathematics that can be applied to daily work after graduation." "Mathematics is taught, not as mental discipline, but as a tool whose use can be acquired only by constant practice on concrete pieces of work." "With this ideal in view, the work in mathematics is made to correlate very closely with the work in the drawing room and shops, and the problems are those that the student meets daily in his work."

Five courses in mathematics are offered in the boys' department:

Mathematics I.—A general review of fundamental operations, roots, and powers, fractions, weights, and measures, mensuration, practical applications dealing with speeds of belts and pulleys, cutting speeds of lathes, screw threads, etc. Algebraic notation and the solution of simple equations.

Mathematics II.—Continues the work of algebra and includes factoring, fractions, fractional and linear equations, simultaneous equations, graphic representation, theory of exponents, quadratic equations, and logarithms.

Mathematics III and IV include the study of plane and solid geometry and trigonometry. Problems having application in drawing and shop work are emphasized. In plane trigonometry, trigonometric formulas, functions of angles and their applications to right and oblique triangles are studied.

Mathematics V.—During the final term, direct application of the previous courses in mathematics is made to the work of the different trades, and the classes are grouped to include those taking closely related courses.

In the academic division of the girls' department of the school, one course in mathematics is offered. This course is described as:

Shop Arithmetic—Review fractions and decimals applied to household arithmetic, sewing measurements, division and multiplication of cookery recipes, household accounts, cost of furnishings and food supplies, and percentage applied to the estimates of cost of living.

Problems are taken from their daily work in cooking, sewing, and millinery, such as drafting patterns, measurement of materials, recipes in cooking, in sewing within definite limits of cost, in cooking for the sick, and in the study of economy. The measurement of materials for hats, flowers, patterns, etc., in the millinery department.

In the elementary industrial schools and classes, little mathematics is taught beyond the more practical aspects of elementary school arithmetic.[15]

[14] *Course of Study*, School of Trades, Portland, Ore., pp. 5–6.

[15] *Report of Committee No. VI, Bu. of Ed. Bul., 1912, No. 4*, p. 34.

The industrial school at Lawrence, Mass., may be taken as typical of this group. In this school, children of fourteen or over are prepared for practical work by taking part-time instruction in the school. Textile and mechanic arts courses three years in length are given. Both day and evening classes are conducted.

The plan of the work in arithmetic[16] is quite similar to that of the apprentice schools which have already been described. Students who are taking the mechanic arts course are given a thorough drill in practical problems connected with the metal and wood trades, and a similar drill in mill problems is given those taking the textile course. Each course has a separate textbook, written by the instructor, the problems being taken from local industries. After the first year, arithmetic is taught only as it is met in the shop.

In the report of the American Commissioners of the International Commission on the Teaching of Mathematics, to which reference has been made repeatedly, a rather unsympathetic statement is made in regard to the courses in mathematics in the elementary industrial schools. The statement reads: "For a certain type of mind they are valuable, but they do not contribute to any considerable broadening of the mind, nor do they seek to add that general culture which has been found to make for happiness and sympathetic interest in the world at large in later life. They tend to close the door to general mathematics, and they are to this field what a course of literature of artisan's manuals would be to the nobler literature of the language."[17] All must of course acknowledge that specialized instruction tends to limit the possibility of general development. There are, however, compensations. Many boys who remain dormant under the ministrations of the teacher of general mathematics are stimulated, awakened, *broadened* when they enter the field of applied mathematics. These boys are teleologists, and if they deserve to be classed as having a "certain type" of mentality, they have for companions the great mass of mankind. In regard to the statement that elementary applied courses tend to close the door to general culture and general mathematics, and consequently lessen one's happiness and sympathetic interest in the world at large, it may be said, first, that the door to general culture is already closed to more than ninety-five per

[16] W. H. Dooley, "Arithmetic in a Massachusetts Industrial School," SCHOOL SCIENCE AND MATHEMATICS, 1911, pp. 246–49.
[17] *Bulletin, 1912, No. 14, U. S. Bureau of Education*, p. 22.

cent of the boys and girls who enter the elementary industrial schools; second, that where there is opportunity, boys may be led from the elementary applied courses into the broader fields of mathematics,[18] in which they study the theory for the sake of its application rather than merely to understand the principle or to get a certain mark, as is the case in general mathematics courses. Moreover, one's happiness and sympathe ic interest in the world at large are conditioned not only by his general culture but by his ability to "hold his job," and the records of all of the apprentice schools show that this ability is greatly increased by the study of applied mathematics.

The evening schools have a rather difficult problem in the teaching of applied mathematics because of the exceedingly varied degrees of advancement and diverse interests of the students who attend these schools. The work must of necessity vary greatly in character in the different schools and localities. If the school's students are relatively homogeneous in their vocational interests, the work is apt to be rather narrowly specialized. Practical problems are necessary to hold the interest of the more mature students. If the school is dealing with a mixed student body, the mathematics is more general. The impression which one gathers from an examination of the texts developed in evening schools and intended for use in such schools[19] is that, in general, the practical character of the mathematics in these schools lies in the selection of those parts of mathematical science which have the greatest application to practical affairs and the elimination of the more distinctly theoretical. Enough practical problems are given to show the possibilities of application and to stimulate interest.

Summary.

We are at present at the beginning of a movement to emphasize the broadly utilitarian element in education. The great extension of human knowledge is compelling us to set limits to the education of the individual more closely than was formerly necessary. The masses are beginning to realize that they have for years been paying for vocational education for the professional classes, while getting none for themselves. They are asking for and slowly receiving advantages similar to those enjoyed by the professional class. Employers of labor are discovering some of the limitations of production by machinery, and as com-

[18] Cf. *Lane Technical School Yearbook*, 1914, p. 84.

[19] For example, see Palmer, *Practical Mathematics*, Parts I-IV.

petition becomes sharper many are turning their attention to the improvement of the employee as a means of increasing production and allaying industrial unrest. Some employers are asking that the public schools prepare youth more adequately along vocational lines, while others are themselves organizing schools for the vocational training of their employees. While these schools are still in the experimental stage, they have clearly demonstrated their efficiency, and with the organization of the National Association of Corporation Schools they promise to become one of the most potent and practical factors in industrial education in the United States. This practical tendency, which is affecting all of our schools, is the keynote of the "New Education." The new education is called "narrow," "prohibitive of general culture," "class education," etc., by the adherents of the "Old Education," while the old education is called "formal," "theoretical," "unrelated to life," "efficiency-destroying," etc., by adherents of the new education, and the honors are even. It is relatively useless to raise one's voice against a world movement. The mathematicians have, in general, recognized this and they are taking measures to bring their subject into line with the new demands of the times.

The mathematics in all classes of schools, vocational and non-vocational, is being affected by these new demands. In the elementary industrial schools, new textbooks are slowly being compiled which present mathematics in terms of the various industries. We at last have some good farm arithmetics suitable for the youth of the country, instead of the dominantly commercial arithmetics with which the rural schools have been fitting their youth for work in the cities for more than a hundred years.

A majority of the secondary technical schools have methods very similar to those in use in the regular public schools. This is particularly true of the public technical schools, which frequently plan to include the mathematics required for college entrance. The laboratory method is not widely used in these schools; the textbook still predominates. The agricultural secondary schools appear to have made the least change from the traditional courses of mathematics of any of our secondary schools.

In the trade schools, on the other hand, the work is much more closely applied to the industries than in the schools mentioned in the preceding paragraph. Although more advanced, the work done is much like that done in the apprentice schools.

All classes of schools teach some form of applied arithmetic. This subject is most highly developed for the commercial high schools, but arithmetics for other fields of industry are being gradually built up by those working with the apprentices in the various industries.

Very little algebra or geometry is taught in the apprentice schools, as they find comparatively little field for the application of these subjects. Some algebra is taught for the sake of learning to interpret formulas, understand cube root, etc., and geometry finds its chief point of application in the field of drawing and design. The geometry taught is largely constructive.

Algebra and plane and solid geometry are usually taught in the secondary technical schools, and trigonometry is a common elective. While many of these schools attempt to develop the applied mathematics point of view (a few giving a course in applied mathematics in the last year), it is evident from the report of the American Commissioners of the International Commission on the Teaching of Mathematics that these more advanced subjects are still presented largely after the traditional fashion.

In many of the trade schools, the traditional bounds of the subjects are disregarded. Courses in arithmetic, algebra, geometry, etc., as such, are not given. The work in mathematics is organized about the individual trades, or about closely related groups of trades. This is an experimental period. Practices in different schools of the same general type vary greatly, but out of this experimentation we may hope to see develop courses in mathematics which will be satisfactory both from the educational and the vocational points of view.

ROCKS ABSORB WATER.

The amount of water held in the rocks or other materials composing the earth varies greatly, owing to many causes. The amount absorbed depends on the porosity of the material, the slope of the surface, and the size and abundance of joint cracks, fissures, and cavities. The amount of water in drift or surface materials is dependent to some extent on the nature of the underlying rock, and the amount which finds its way into the solid rocks is dependent on the thickness of the overlying surface deposits. The amount of water contained in the earth's crust (to a depth of three miles) has been estimated by different writers, with widely different results. A recent estimate is given by Fuller, of the United States Geological Survey, Department of the Interior, who concludes that the total amount of free water in the earth's crust would be equivalent to a uniform sheet over the entire surface of the earth having a depth of about one hundred feet. This is but a small fraction of the estimate made by other writers.

A MATHEMATICAL CONTEST.

By Edgar T. Boughn,
Principal, Perris Union High Schoo', Cal.

Two teams of boys and girls, representing the Manual Arts High School, Los Angeles, and the Pasadena High School, recently engaged in an interesting mathematical contes', in which the Pasadena High S hool was victor by a close margin.

Rules To Govern Contest.

1. Each team shall consist of five members.

2. Each member must be a regularly enrolled (regularly enrolled to be understood as having entered the ninth grade not earlier than September, 1915, and not having failed or repeated any part of the ninth-year algebra) pupil of the ninth year.

3. In competition one pupil from each school shall compete at a time under the following conditions:

(*a*). The two pupils in competition shall work at separate blackboards, or at the same board screened from each other.

(*b*). A reader will read or state a problem to be solved by the competitors, who must copy the sta'ement of the problem.

(*c*). A judge for each competitor shall (after the competitor has indicated that he has completed his work and plainly marked the result "*Ans.*") signal to the reader, if the work is correctly done. (Under no circumstances shall this judge volunteer any information or make any signal, unless the work is correctly done.)

(*d*). The reader shall decide which judge has first signaled that a competitor has completed his work and, in case of an appeal by a competitor as to correctness of work done or failure of a judge to signal properly, shall determine whether or not another problem shall be substituted and solved by both competitors in place thereof.

(*e*). Each school shall provide a scorer whose duty shall be to keep posted openly and correctly the scores of each pair of competitors, and sum the total scores at the completion of the competition.

(*f*). The reader shall announce to the scorers, at the completion of the solution of each problem, "Score one for ———— (School)."

(*g*). Each pair of competitors shall be given ——— problems. Each problem solved first in point of time, and correctly solved, shall count one in the scoring.

4. The reader and judges shall be selected by mutual agreement of the competing schools.

5. Attached is a list of type forms mutually agreed upon by the two schools for guidance of the reader.

TYPE FORMS OF PROBLEMS.

I. *Factoring.*

$m^2x^2 \pm 2mnxy + n^2y^2$ $\quad$ $ax^2 \pm bx \pm a$

$x^2 \pm ax \pm b$ $\quad$ $a^2x^2 - b^2y^2$

$m^2 \pm 2mn + n^2 - a^2k^2$ $\quad$ $x^3 \pm a^3$

II. *Special Products.*

$(ax \pm by)^2$ $\quad$ $(m \pm n \pm a)(m \pm n \pm a)$

$(m+n)(m-n)$ $\quad$ $(x \pm a)(x \pm b)$

$(a \pm b \pm c \pm d)^2$ $\quad$ $(ax \pm by)(cx \pm dy)$

$(a \pm x)^3$

III. *Fractions.*

(*a*) Problems in addition and subtraction.

(*b*) Problems in multiplication and division.

These problems shall not involve any types of factoring or special product not shown in I and II, and no problem shall contain more than two fractions. The object is to illustrate the simple types of fractions.

IV. *Equations.*

(*a*) Solution by factoring:

$$x^2 - a^2 = 0$$
$$x^2 \pm 2ax + a^2 = 0$$
$$ax^2 \pm bx \pm c = 0$$

(*b*) Simultaneous equations:

$$ax + by = c$$
$$a^2x^2 + b^2y^2 = c^2$$

Note.—Not more than three problems shall be selected from III and IV for any pair of competitors.

HICKORY NUTS A HUNDRED TIMES OLDER THAN THE WHEAT FOUND IN THE PYRAMIDS.

Among the fossils recently discovered by the United States Geological Survey, Department of the Interior, are remarkably well-preserved impressions or casts of leaves of several extinct varieties of ash, oak, beech, and hickory, which were found, along with three present-day species, in states bordering the Gulf of Mexico. Although the leaves themselves have rotted and gone, here and there some were buried in soft clay by sediment in such a way as to leave perfectly preserved impressions. The nuts, on the other hand, neither decayed nor petrified, but fell into pools of stagnant water, which is one of the best preservatives in nature, and sooner or later were also buried under silt and clay. Owing to their hard coats, those which fell into places favorable to their preservation are today in excellent condition, though slightly flattened by the long soaking and the gentle pressure of the clay. The deposit in which the leaves and nuts are found is not less than a million years old, or at least a hundred times as old as the pyramids of Egypt.

The report containing descriptions and reproductions of photographs of these fossil remains (*Professional Paper 98-L*) is purely technical and may be obtained from the Director, Geological Survey, Washington, D. C.

MEASURING THE VALUE OF LABORATORY EXPERIMENTS IN PHYSICS.

By G. W. Stewart,
State University of Iowa, Iowa City.

Every high school teacher of physics wishes that he might have a method of measuring the results of his efforts, but, unfortunately, methods of satisfactory measurement in this field have not yet been developed. But are we not prepared to take a step in the right direction? For the purpose of illustrating what such a step might be, consider the construction of a beam balance. We test the accuracy of such a balance by measuring the results which it gives as a weighing machine. Suppose, however, that we do not have any standard masses at our disposal for testing, would it not be possible to make measurements of the distances between knife edges with the object of ascertaining whether or not the balance is of accurate theoretical construction? Obviously, such a procedure is not a method of testing the accuracy of the results themselves, but is it not a step in the right direction? In educational work, where we cannot measure the results directly, do we seriously endeavor to examine and to measure the theoretical organization of our instruction? I think not. As a case in point, are we not content with what might be called a general judgment of the relative superiority of laboratory experiments, rather than with a serious effort at a reasonably accurate estimate?

Every instructor has a very good opinion of his "general" judgment in regard to the value of an experiment in his laboratory. Is this confidence warranted by the facts? Ask him upon what he bases his judgment, and he will make a response which indicates that his standards are almost wholly intra-laboratory ones. The actual interest in the experiment shown by the student, the student's satisfaction obtained through the consistency of his results, and numerous other intra-laboratory factors will enter into the instructor's judgment. But are the factors which enter *prominently* into the instructor's judgment the ones which he would *emphasize* in a serious consideration of the purposes of laboratory instruction in physics? The definite conviction of the writer is that they are not.

The purpose of this discussion is to call attention to a method of evaluating a laboratory experiment that is a distinct improvement over a "general" judgment. Only he who admits freely

the possibility of an improvement can be expected to approve of the method suggested.

The method involves three steps. First, there is carefully determined the most important purposes of laboratory instruction. Then follows a decision as to the relative values of these purposes. This can be recorded in the form of a table of numerical values. The values should show the "weight" which the instructor gives to each purpose and, for convenience, the total should be one hundred. Finally, the instructor applies this adopted scale of measurement to his laboratory experiments. In the case of each experiment, he judges the degree to which each purpose is fulfilled, and grades accordingly. This critical analysis not only points out to the instructor the strength and weakness of each experiment, but it also enables him to reach his own *best* judgment as to the relative values of the experiments.

The instructor will at once object to the suggested method on the ground that it involves a considerable amount of work without any assurance of results that justify the effort. For the benefit of such a doubting one, I beg to relate the following experience. Thrice has the writer taught a class in a study of the "Teaching of Physics" wherein laboratory experiments were given the entire consideration. Each class adopted the grading method just suggested, after several weeks' consideration of the purposes of laboratory instruction in physics. Thirteen experiments selected from well-known high school manuals were studied critically by this grading system. In addition to the grading or "weighing" of desirable features, the students suggested improvements in the experiments. At the conclusion of this experience, the class again considered the merits of the grading system actually used. In the opinion of the teacher and in the opinion of all the members of each class, the following points were brought out clearly:

1. The careful consideration of the purposes of laboratory experiments in physics and the subsequent adoption of a grading system in which the factors are "weighted," gives an instructor a perspective which is very different from that formerly utilized in a *"general"* judgment.

2. The only way to obtain a judgment that is one's best is to face each important consideration, as given in the grading system, fairly and singly. This a "general" judgment cannot do. The gain through the use of a grading system amply rewards the instructor for his effort.

3. Through critical study of laboratory experiments, with the view of applying the grading system, improvements are suggested in the grading system itself. This demonstrates that one's opinion changes rapidly with such a critical study. Unquestionably, the rapid change is a clear proof of the inadequacy of the bases of the earlier "general" judgment.

4. Such a method of grading produces a change in judgment on the part of the instructor by broadening his outlook and by making him more alert to recognize the broad requirements of a laboratory experiment, rather than requirements which the environment of the laboratory would establish. In other words, the grading system furnishes a method of securing real progress in laboratory instruction.

It must be clearly understood that this discussion does not advocate the permanent retention of any grading system, for, as the opinion of the instructor changes with the critical study involved in the application of the system, so must the grading system itself be modified. The suggestion does not, therefore, set up a ***permanent*** standard.

The writer wishes to avoid any intimation that he has secured a satisfactory grading system. Indeed, the thoughtful reader will have observed that the system, in order to be valuable, must be one's own. Yet, for the sake of clearness, it seems necessary to append a grading system. There is therefore presented a system adopted by one of the classes to which reference has been made. It is as follows:

Each experiment[1] should:

1.	Produce an inquiry and a means of answering it	25
2.	Furnish opportunity for thinking[2]	25
3.	Cultivate appreciation of environment	18
4.	Furnish opportunity for application of knowledge	11
5.	Give valuable knowledge of facts	11
6.	Establish transferable ideals	10
		100

Explanation of the items in the foregoing system will not be given, for the discussion is not presented for the purpose of establishing a clearly defined system for all instructors, but rather in order to encourage each instructor to adopt his own.

As presented, the system seems to refer chiefly to high school

[1] It is assumed that each experiment can be performed within the laboratory period.

[2] By the word "thinking" is meant a complete process of thought which, according to Dewey, involves the following logically distinct steps: (1) A felt difficulty or problem; (2) its location and definition; (3) suggestion of possible solution or explanation; (4) development of reasoning of the bearings of the suggestion; (5) further observation and experiment leading to its acceptance or rejection.

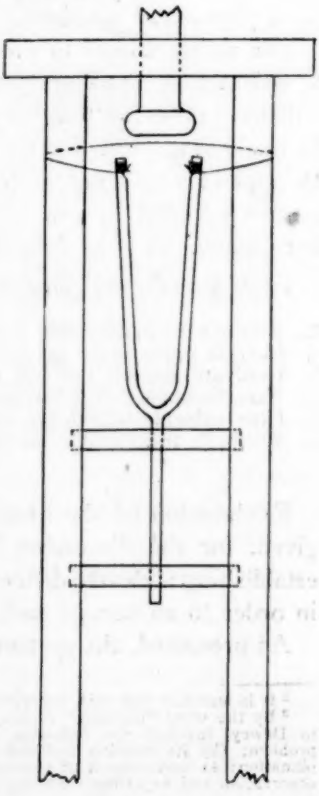
physics. It is, however, equally applicable to college instruction.

The writer presents this discussion with hesitation, for he knows that it is destined to meet with much skepticism. Actual experience has, however, strengthened his conviction that the suggested grading system is decidedly helpful. Indeed, the idea of the grading system here presented is *new* only in the sense of its successful *application* to *laboratory experiments*. If experience has shown a decided value for a grading system in animal husbandry, in oratory, in debate, and in numerous other fields wherein a judgment must be rendered, cannot the *ideal* be transferred to laboratory instruction? May the instructors of physics who read be willing to test the worth of the suggestion by actual trial!

ACCELERATION APPARATUS.

By Roy C. Andrews,
University of Oregon.

Users of the falling tuning fork apparatus for determining the acceleration due to gravity have experienced difficulty because the trigger release which sets the fork vibrating also gives it a slight downward impulse. Hence the space passed over in the first interval is greater than it should be for a body falling from rest. The following method overcomes this difficulty:



Tie a piece of thread to one prong of the fork, carry it around both pillars, and tie to the other prong. The weight of the fork and its guides is sufficient to spread the prongs slightly, while friction will prevent slipping. To release the fork, simply touch a lighted match to the thread at its middle point. Results by this method and by the old method are given for comparison.

	New Way.				
Interval of 10 vibrations	1	2	3	4	5
Total distance = s cm.	3.5	14	31.7	56.5	88.6
Distance in period = d	3.5	10.5	17.7	24.8	32.1
Acceleration = a = 7.12	7	7	7.2	7.1	7.3
Comparative distances, $\frac{s}{\frac{1}{2}a} = t^2$	.98+	3.9+	8.9+	15.9	25
Nearly	1	4	9	16	25
Comparative distances, each period, $\frac{d}{\frac{1}{2}a}$	.98+	2.9+	4.9+	7	9
Nearly	1	3	5	7	9
Vibrations per second	117				

$$g = \frac{a}{t^2} = \left(\frac{\frac{a}{10}}{117}\right)^2 = \frac{7.12 \times (117)^2}{100} = 975.$$

	Old Way.				
Interval of 10 vibrations	1	2	3	4	5
Total distance = s cm.	6	18.6	38.4	65.5	98.8
Distance in period = d	6	12.6	19.8	27.1	33.3
Acceleration = a = 7.12	12	6.6	7.2	7.3	6.2
Comparative distances, $\frac{s}{\frac{1}{2}a} = t^2$	1.5+	4.7	9.7	16.6	25.1
Comparative distances, each period, $\frac{d}{\frac{1}{2}a}$	1.5	3.2	5	6.9	8.4
Vibrations per second	117				

$$\frac{7.86 \times (117)^2}{100} = 1076.$$

COCOA.

The plant from which the alkaloid, cocaine, is obtained (*Erythroxylon coca*) belongs to the Linaceae or flax family and is a native of Peru and Bolivia. It is a shrub six or eight feet high. The leaves have long formed an article of trade among the natives, for which purpose the shrub is extensively cultivated. The leaves are used, either infused in tea or chewed with a small quantity of powdered lime, which is carried on long journeys in a small gourd. It appears to have been generally used by miners or those making long journeys without the means of securing food, as it lessens the desire for food and produces a feeling of increased energy. An immense amount of fatigue can thus be undertaken combined with a pleasurable effect. When used in moderation it seems to act as a powerful stimulant, but in excess it produces a kind of intoxication of the nature of opium and the consequence of its prolonged use is quite as injurious, so that the habitues among the natives seldom live long. Dr. Spruce, the well-known South American traveler and botanist, says that the native with a chew of coca in his mouth will often go without food for two or three days without feeling any wish to sleep.—[*American Botantist.*

AN EXPERIMENT IN MAGNETISM.

By R. M. Holmes,
University of Maine, Orono, Me.

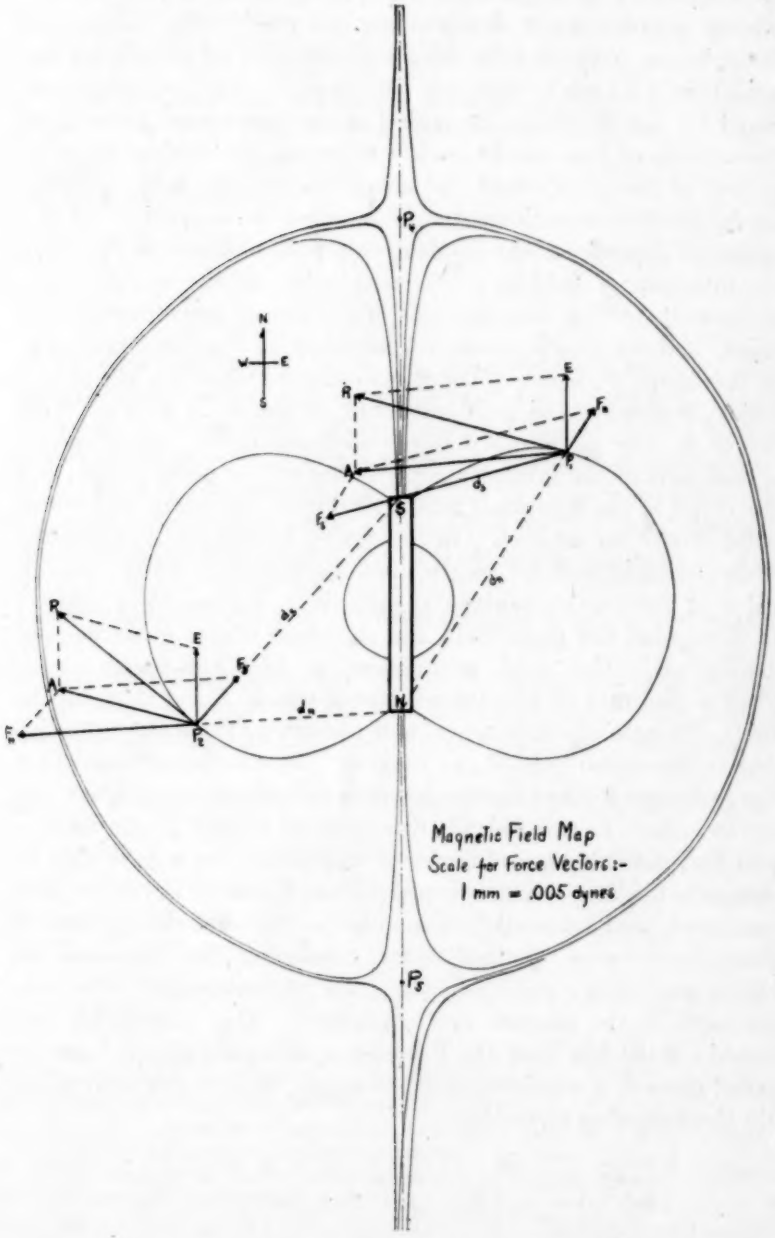
A student taking a course in general physics is apt to lose the connection between the various divisions of the subject. In most such courses mechanics and magnetism are separated by several months' work along other lines, and it seems very desirable that a review of some of the most fundamental principles of mechanics might well accompany the study of magnetism and electricity.

With this thought in mind, the writer has used an experiment combining many of the laws of mechanics and magnetism. This experiment has been very satisfactory to both instructor and student, and it is believed that it could be used with equally good results in secondary schools. The method is graphical rather than analytical, and probably on that account leaves a more vivid impression on the mind of a beginner. A further advantage lies in the fact that the apparatus used is of a very simple character and is available anywhere.

The procedure may best be explained by reference to the figure which was made by a student in a general laboratory course. The drawing paper was tacked to a drawing board and arranged so that its edge was approximately in the magnetic meridian. By means of a pocket compass, a line was drawn through the center of the paper and in the magnetic meridian. Parallel to this line, two other lines were drawn far enough apart to coincide with the edges of a short bar magnet. The magnet was then placed on these lines with its north pole pointing south, and was fixed in place by brass pins along its sides.

A few lines of force were drawn by use of a compass about 1 cm. in diameter. The usual method of making a dot at one end of the needle, and then advancing the compass so that the other pole would come vertically over the dot, was followed. Two lines starting from the sides of the magnet were sufficient to give a general idea of the field in that vicinity. Lines were also started from the ends and these, together with some started from the north and south edges of the paper, served to locate the neutral points or regions where the field due to the magnet just balanced the field of the earth. It was not possible to locate these points with any great accuracy, owing to the lack of sensitiveness of the compass needle and to the fact that its two ends were in different parts of the field. The distances be-

tween a neutral point and the two poles of the bar magnet gave a method of calculating the pole strength from the known value of the earth's horizontal intensity.



The second part of the experiment was to determine the period of a magnetic pendulum in the earth's field, and then its period at a point on the line of force. A magnetic pendulum was made by suspending a magnetized piece of a coarse needle from a wooden support stand, using a fine silk fibre. The needle was about 5 mm. long, and the fibre was obtained by separating the strands of a length of ordinary silk thread. The pendulum was timed by a stop watch, its period being determined by making three trials of ten swings each. Knowing the horizontal component of the earth's field and using the law that field strengths are inversely proportional to the squares of the periods of the magnetic pendulum, the student was thus enabled to calculate the intensity of field at the chosen point on the line of force. A tangent to the line of force was then drawn through the point, and its length made proportional to the field strength. In the figure, P_1 is one of the points selected, and R is the vector which represents the total intensity of the field at P_1. This vector R may be resolved into two components, one of which is that part of the intensity contributed by the earth's field, and the other is the combined intensity due to the north and south poles of the bar magnet. In the figure, E is drawn in the magnetic meridian and its length made proportional to the known value of the earth's horizontal intensity. It was then possible to determine the magnitude and direction of the other component of R. This other component is A in the figure. A is itself a resultant of two forces, one of which, F_n, is that due to the north pole of the magnet, and the other, F_s, is the intensity due to the south pole of the magnet. It may be assumed that the poles are located on the geometrical axis of the magnet and at the ends. In this case the directions of F_n and F_s are known, and the parallelogram of forces of which they are a part may be completed. The vectors representing F_n and F_s were then measured, and from the scale adopted the numerical values of these forces were obtained. By measuring the distances between the chosen point and the poles of the magnet, the pole strength of the magnet was calculated. This calculation was based on the law that the force on a unit pole situated at any point distant d centimeters from a pole of strength m is given by the following equation,

$$F = \frac{m}{d^2}$$

By these methods it is possible to obtain a value for the pole strength, using the distances between the neutral points and their adjacent poles, and two more values for each point selected for the location of the ends of the force vectors. In the figure, two such points were taken. The numerical values follow.

(1) Pole strength determined by neutral points.

Distance from south pole to adjacent neutral point (cm.)	11.8
Distance from north pole to adjacent neutral point (cm.)	11.4
Mean (cm.)	11.6
Length of magnet (cm.)	9.0
Pole strength of magnet	31.5

The equation used for calculating the pole strength is

$$\frac{m}{d^2} = .16 + \frac{m}{(d+l)^2},$$

where m is the pole strength, .16 represents the value of the horizontal component of the earth's field, d is the mean distance from the poles to their adjacent neutral points, and l is the length of the magnet. The equation is obtained in the following manner: The strength of the field at P_4 is zero, which is the resultant of three components. The first of these components is the intensity due to the nearer pole of the magnet, this intensity being given by $\frac{m}{d^2}$. This is the only component directed toward the magnet, the two others being oppositely directed. These other components are the intensity due to the earth, which is known to be .16, and the intensity due to the north pole of the magnet which is given by $\frac{m}{(d+l)^2}$. Since the field is zero at P_4, and since the last two components are directed exactly opposite to the first, it follows that the first must equal the sum of the other two. By similar reasoning, the equation will be found to hold true for the point P_5.

(2) Pole strength determined by magnetic pendulum and force vectors.

T = Period of magnetic pendulum (sec).
R = Field strength at chosen point (gauss).
d_n = Distance from point to north pole of magnet (cm.).
d_s = Distance from point to south pole of magnet (cm.).
F_n = Field strength at point due to north pole of magnet (gauss).
F_s = Field strength at point due to south pole of magnet (gauss).
m = Pole strength from equation $F_n = \frac{m}{d_n^2}$ or $F_s = \frac{m}{d_s^2}$.

The period in the earth's field was 2.9 sec., and the strength of the horizontal component of the earth's field in the laboratory was taken to be .16 gauss.

Point.	T sec.	R gauss.	d_n cm.	d_s cm.	F_n gauss.	F_s gauss.	M_n	m_s
P_1	1.7	.46	13.0	7.3	.11	.52	19.	27.
P_2	1.9	.37	8.7	13.0	.39	.13	29.	22.

The mean value of m from these observations, assuming m_n to equal m_s, is 24.2.

It is obvious that close agreement between the different values of m could not be expected from this method. The periods of the magnetic pendulum were determined only very roughly while their squares entered into the calculations. Also, when the pendulum was vibrating, its two poles were in different parts of the field. The tangent to the lines of force do not give the direction of the resultant field at the selected points accurately, owing to the observer's inability to draw an exact tangent to the curve. The principal value of the experiment lies in the clearness with which it presents so many of the fundamental facts of magnetism and mechanics.

CLASSROOM SAYINGS.

A fireless cooker is a good deal like the gas stove, but it does not burn gas. It is so wasteful that it hardly pays.

In answer to the question, "Describe the metallurgy of iron," the following was given: "First melt the iron, and then pour into a solution of hydrogen."

Drawfiling is holding the file by both hands.

Dew point is when the temperature is cooled below exaggeration.

Teacher: "What is a transparent body?"
Bright Young Lady: "A transparent body is one that you can see through."
Teacher: "Give an example."
Bright Young Lady: "A ladder."

The original spelling has been preserved in the following statements:

Cotton has been grown since *immorable* times in history.

This fragrance was formerly supposed to be due to volatile oils, a theory which has since been proved *enormous.*

We tested with nitrigasit for prodeid.

Sulphur comes in sulphur rolls, cakes, flowers of Sulphur.

A genus is a tree together. A specie is a tree of same kind.

The reasons for call the potatoe is stem that the stem is attached on the potatoe so it must be part of it.

The parts of a fibrovascular bundle are the sievtudes, ducats, medulary rays.

The "dandoline"—an example of a stem which protects itself by "poisonous matter."

The leaves are for phosymethes.

And again—"Leaves—for photosmpheses work."

They are called lenticels because they cannot be seen without a lens.

A PLEA FOR THE STUDY OF ELEMENTARY ASTRONOMY.

By Wilbur F. Hoyt,
Normal School, Peru, Neb.

Astronomy Always an Essential Element of Culture.

Astronomy was the first-born of the sciences, and early grew to a stature that overshadowed all others, down even to the nineteenth century. Before men had any intelligent conception of their own bodies, of the world they inhabited, or their immediate environment, the trees, plants, animals, and minerals of their daily life, they had accumulated a considerable store of knowledge of the heavenly bodies and their movements. Astronomy was considered an essential part of intellectual culture and development. Two generations ago it had attained position as an exact and completed science, excepting minor details that better telescopes might yet reveal. The invention of the spectroscope and instruments for measuring infinitesimal degrees of light and heat, and the use of the photographic plate in astronomical observation, have so revolutionized the science that Kepler, LaPlace, and Herschel would be astounded at the change.

Teachers of Astronomy and Curricula Makers at Fault.

Pari passu with the marvelous advances and development of scientific astronomy have gone the decline of interest in and the popular presentation of the subject in the schools. Most of the blame for this condition lies at the doors of the teachers of the subject, and the curricula makers. There is no call for the higher mathematics that bars the student from elementary astronomy. Nothing more difficult than algebra and plane geometry, with the possible inclusion of a formula or two from trigonometry, requiring no especial knowledge of the subject by the student, is needed for the presentation of the simple facts relating to the earth, the heavenly bodies, their movements, and a clear conception of the great discoveries and hypotheses of the science. No man can lay claim to a broad culture, without at least an elementary knowledge of the solar system and the starry universe. Scientific astronomy is in safe hands, and will continue its triumphal progress; irrespective of our attitude toward it, but our attitude toward a general diffusion of elementary astronomy is of vital importance to ourselves and the general public.

Awakened Interest in All Subjects of Nature, Save the Astronomical.

There is an awakened interest in the facts and phenomena of

nature, in the schools, with one conspicuous exception—the nightly procession of the heavenly bodies. And yet, in many respects, the latter is more fundamental and accessible than any of the others. One may easily go, and often does go, where familiar faces, animals, plants, stones, and landscape features are not to be found at all, but there is no place on the face of the earth where some of the familiar constellations and members of the solar system do not pass in review. One's dooryard almost anywhere on God's footstool is a good viewpoint for the study of astronomy. Anyone with good eyes is as well equipped as the Patriarchs and the Magi who caught a clear vision of the numbers, movements, and importance of the heavenly bodies. Anyone with a good opera glass is nearly as well equipped as the illustrious Galileo. Most of us are within easy reach of telescopes, through which

> Will Holy Science, putting off
> Earth's dusty sandals from her radiant feet,
> Survey God's beauteous firmament unrolled
> Like to a book new-writ in golden words,
> And turn the azure scroll with reverent hand,
> And read to *us* the wonders God hath wrought.

Elemental Facts of Other Science Unintelligible Without Astronomical Knowledge.

This appeal should interest teachers especially. Many years' experience with teachers has convinced me that a host of familiar facts of geography are not clearly understood for want of a knowledge of elementary astronomy. How are the shape, size, mass, and movements of the earth determined and demonstrated? Does the average teacher comprehend the various movements of the sun, moon, planets, and stars, and the results of these motions? Why is the tropical year shorter than the sidereal? How is exact time determined, and where is the regulating clock located? How are latitude and longitude established? Why is the prime meridian located at Greenwich rather than London? How and why do the degrees of latitude vary as we go toward the poles? These are not a tithe of the perplexing questions that the teacher of geography must face, and the answers involve an elementary knowledge of astronomy. Think of the confusion that would reign on land and sea if astronomy did not detect and provide for the correction of the variations of the magnetic needle! "They that go down to sea in ships, that do business in great waters," must be practical astronomers, if they would reach "their desired haven." Not many students or teachers themselves can give correct and clear explanations of the causes

of the tides, or of the changes of the seasons. If there are any at all who have not studied elementary astronomy, they have successfully eluded my earnest search, and I am personally convinced "There is no such animal." Geology has been aptly termed, "domestic astronomy," and it is a Sisyphean task to attempt to understand or to teach many of the facts concerning the origin and development of the earth without some knowledge of astronomy. Physics and chemistry have found the solution of many of their most difficult problems in the astronomical field. It is necessary to mention only the laws of gravitation, the velocity of light, and the evolution of the elements to establish that fact. Long before the discovery of radium and radio-activity, astronomy had indicated that the elements are not stable nor eternal, a fact of which Haeckel took advantage in his hypothesis of the evolution of elements from a fundamental substance which he called "prothyl," and which the modern scientist believes to be the ether, or possibly electricity itself. Every stage and phase of this evolution are blazoned on the heavens in letters of light from shining nebulae and dazzling stars. Historical facts and events have been verified also, and correctly dated by contemporaneous eclipses and comets. Despite all this evidence, an interesting and readable article from the pen of a widely known journalist—may the saints rest their souls, and grant them leisure and inclination to acquaint themselves with a few fundamental facts before tackling scientific topics!—stated that astronomers, cultured and estimable gentlemen as they unquestionably are, are sacrificing their lives and their great talents to a task that is not and could not possibly be of any advantage whatever to mankind, urged on by a love for pure science. It would be of interest to know whatever that term meant to that able journalist. Wide of the mark as that article was, it stated precisely the conception and attitude of the general public toward astronomy—an absorbing study of the marvelous facts concerning *heavenly bodies*, a consideration of which may well be postponed till St. Peter has validated their passports, and they may study these objects at closer range!

Astronomy Has Both Cultural and Utilitarian Values.

The study of astronomy has cultural as well as utilitarian values. It constitutes the last great step of ascent, and the consequent widening of the horizon of intellectual life, beginning with the home, and including the community, the country, the world,

and, lastly, the cosmos. The astronomer is the only true cosmopolitan—the citizen of the universe. Holden says in substance: "If you should transport me to the uttermost star, I should still feel at home in the universe of my God, surrounded by familiar materials and familiar forces." The astronomer alone deals with infinities of space and time, and the well-nigh infinitudes of mass, and force, and velocities. Newcomb said the most overwhelming thought that ever came to him through the study of science was that he was a denizen of a mighty globe, whirling rapidly on its axis, and circling a stupendous sun which it accompanies in its headlong flight through the universe, its present direction known to him, but its destination and the obstructions that may lie in its path, God Himself only knows. With the Quaker poet, he might well have added:

I know not where His islands lift
Their fronded palms in air;
I only know I cannot drift
Beyond His love and care.

Astronomy the Great Unifying Science.

Astronomy has done more to establish the marvelous unity of matter, of energy, and of God, than all other sciences combined. Far be it from us to discount the marvels of the microscopic and ultramicroscopic worlds, or of the bacterial and grosser forms of life, or of the facts and phenomena of the finite world about us, but yet the masses, and forces, and beauty of order and arrangement of the starry universe impress one as being on a more godlike scale than the others. The ancient Greeks and Romans might well believe in a god for every reality and circumstance of nature, but to the modern scientist, and particularly to the astronomer, God is God, and Jehovah is his name. Superstitious beliefs have no place in the creed of the astronomer. Despite his familiarity with our lunar neighbor, he continues to plant his potatoes in good, rich loam, at the proper season, irrespective of the phase of the moon. The appearance of a comet, meteor, or eclipse is a portent only of the reign of law.

Astronomy a Cure for Narrowness and Selfishness.

The study of astronomy is an excellent antidote for narrowness and selfishness. A bright student said, "No man at home with the friendly stars is likely to rail at his neighbor for crossing his half-acre lot." Astronomy furnishes one of the most delicate tests for literacy or illiteracy. Few people preparing a more or less profound thesis, or popular article, or delivering

a more or less dignified address, can resist making some allusion to the starry heavens, and a very large percentage of these allusions are based upon or buttressed by illusions as to astronomical phenomena. A little learning may be the dangerous thing the proverb proclaims it to be, but abysmal ignorance is not less dangerous, and most of the references to the stars are not founded upon even a little knowledge.

Four Great Hypotheses

There are four great hypotheses advanced to account for the origin and development of the solar system and the earth, each with its advantages and disadvantages, and each with its adherents today. Perhaps each has contributed more or less to the evolution of the stellar universe. These theories do not demand any profound technical knowledge of astronomy, but an elementary acquaintance with the science is a *sine qua non* of any clear comprehension of any of them. The limits and purpose of this article forbid anything more than brief mention of them. LaPlace's *Nebular Hypothesis*, the most brilliant as well as the first of these, suggested by Saturn's system of rings, held sway for a hundred years. Curiously enough, Saturn's system of rings is one of the chief difficulties in the way of general acceptance of this theory today. Lockyer's *Meteoric Hypothesis*, suggested no doubt by the millions of meteors plunging into our atmosphere every twenty-four hours, followed but never attained the popularity of its predecessor. Arrhenius's *Cosmic Dust Hypothesis* seems to accord well with some observed facts, such as formless and diffuse nebulae, cometary tails, zodiacal light, etc., but it has never received general assent as the principal method of world formation. The *Planetesimal Theory* of Chamberlain and Moulton seems to have superseded the theory of LaPlace in popular estimation, and it avoids most of the difficulties in the way of all the others. It is based also upon the hundred thousand spiral nebulae, and the not-infrequent appearance of temporary stars. Surely, the time and effort spent in the mastery of these are as cultural as the time and effort spent on the details of Caesar's rickety bridge, or in grubbing out of a dictionary how many parasangs Cyrus marched with his cohorts.

Astronomy Produces Great Men.

Astronomy has furnished, and is still furnishing, more than its full quota of world-famous men; Ptolemy, Copernicus, Galileo, Kepler, Newton, LaPlace, the Herschels, and our own Young, Newcomb, Keeler, Hale, Lowell, the Pickerings, Barnard, Camp-

bell, and others too numerous to mention. It is an education to know of these men and their accomplishments, and it is crass ignorance not to know something of them. Astronomers have fashioned and used the most perfect and powerful of instruments ever invented by man, the telescope, spectroscope, spectroheliograph, micrometer, pyrheliometer, and other marvelously accurate meters of light and heat. The cultured man should know at least some of the miracles performed with these instruments. It is of interest, and a matter of pride to us, that America has more great telescopes and observatories, and has made more great discoveries in astronomy in recent years than any other country. Indeed, we need not shrink from comparison with all the rest of the world beside.

EVEN A BRIEF COURSE IS HIGHLY REVEALING AND STIMULATING.

One semester, or better one year of elementary study of astronomy, will put the student in touch with the great characters and accomplishments mentioned above. What other study can offer so great a return for so meager an investment of time and energy? Why should not the great mass of pupils who pass through our public schools get at least a glimpse of the facts and phenomena of the universe, and have suggested to them the profoundest thoughts and conceptions ever formulated by the human mind? Anyone furnished with even an elementary training, such as suggested above, sees in the wintry sky not only a firmament inlaid with jeweled stars, but he can point to this and that bright star as a gigantic sun, far outrivaling the one upon which we rely for heat, light, energy, and life. Some of these he knows to be plunging through space at almost inconceivable speed, suggesting that the universe must include much more matter than the incandescent materials revealed by the telescope. That little smudge of light he knows is the stupendous Nebula of Orion, a seething mass of incandescent gases sprinkled with many suns that probably equal or surpass our own. It is an awe-inspiring, flaming forge in which God is still fashioning solar systems and worlds. Another tiny smudge is the so-called Nebula of Andromeda, a gigantic whirlpool of stars coursing through space at the rate of approximately four hundred miles per second—eight hundred times the velocity of a modern projectile. This tiny star is a splendid double solar system, one sun an orange color, the other an olive green. This other one is a wonderful quadruple system. Here and there are massive clusters of stars, revealed only by large telescopes,

having many more stars than the unaided eye has ever seen in the whole sky. A photograph taken in this part of the Milky Way shows four hundred thousand stars on a single plate! That reddish "star" is Saturn, the ringed miracle among worlds with its ten satellites. This other is Jupiter, a gigantic world in the making, like the earth in geologic times, only vastly larger, and furnished with nine moons. Our own satellite is a dead world, but marvelously beautiful even in death. The sun is not a disk of burnished gold even to the amateur astronomer, but a monster globe of incandescent gases, surrounded by envelopes of cooler gases, agitated by electromagnetic cyclones and outbursts so intense as to influence our tiny earth 93,000,000 miles away. Even the tyro in astronomy is never alone, nor in want of food for thought, and exercise for his imagination, the flights of which have a multitude of solid resting places, from which he may plan other flights. With Kepler he "thinks God's thoughts after Him!" "Lo, these are parts of His ways, but how little a portion is heard of Him!"

COAST AND GEODETIC SURVEY CHARTS TO BE DISPLAYED IN POST OFFICES.

Arrangements have been made with the Post Office and Treasury Departments by which the charts and nautical publications of the Coast and Geodetic Survey will be brought to the attention of the public in the principal seaport cities on the Atlantic and Pacific Coasts and at some cities in the interior.

A framed copy of the most important chart of the locality will be placed in a prominent position in the lobby of the post office in each city, together with a placard containing information as to how the charts and publications may be obtained.

The results obtained by the Survey are published in charts on various scales, including sailing charts, general charts of the coast, and harbor charts; tide tables issued annually in advance giving the time and height of the tides at all the principal ports in the United States and at some foreign ports; Coast Pilots with sailing directions covering the navigable waters; Notices to Mariners (published jointly by the Coast and Geodetic Survey and the Bureau of Lighthouses) issued weekly and containing the latest information necessary for safe navigation; catalogues of charts and publications, and special publications on the subjects of geodesy, terrestrial magnetism, and other subjects pertaining to the work of the Survey.

The charts, Coast Pilots and tide tables are sold at the office of the Survey in Washington, at the sub-offices of the Survey, and by agents in the principal cities. Prices are given in the Chart Catalogue which is supplied to applicants without charge. List of publications available for free distribution may be obtained from the Division of Publications, Department of Commerce.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Trigonometry.

500. *Proposed by Nelson L. Roray, Metuchen, N. J.*

In any triangle show that

$$\frac{a^2 \sin (B-C)}{\sin B+\sin C}+\frac{b^2 \sin (C-A)}{\sin C+\sin A}+\frac{c^2 \sin (A-B)}{\sin A+\sin B}=0.$$

I. *Solution by R. M. Mathews, Riverside, Cal.*

By the law of sines, $\sin B=\frac{2b}{R}$, where R is the radius of the circumscribed circle.

By the law of cosines, $\cos B=\frac{a^2+c^2-b^2}{2ac}$.

$$\frac{a^2 \sin (B-C)}{\sin B+\sin C}=\frac{a^2 (\sin B \cos C-\cos B \sin C)}{\sin B+\sin C}$$

$$=\frac{2a^2R\left\{b.\frac{a^2+b^2-c^2}{2ab}-c.\frac{a^2+c^2-b^2}{2ac}\right\}}{2R\ (b+c)}$$

$$=a\left(\frac{b^2-c^2}{b+c}\right)=ab-ac.$$

In a similar manner, the two other terms of the proposed sum give $bc-ba$ and $ca-cb$, whence the required result.

II. *Solution by Nelson L. Roray, Metuchen, N. J., and E. Kesner, Salida, Col.*

$$\frac{a^2 \sin (B-C)}{\sin B+\sin C}=\frac{2a^2 \sin\frac{(B-C)}{2}\cos\frac{(B-C)}{2}}{2 \sin\frac{(B+C)}{2}\cos\frac{(B-C)}{2}}$$

$$=\frac{2a^2 \sin\frac{(B-C)}{2}\cos\frac{(B+C)}{2}}{2 \sin\frac{(B+C)}{2}\cos\frac{(B+C)}{2}}$$

$$= a^2 \frac{\sin B - \sin C}{\sin (B+C)}$$

$$= a^2 \frac{\sin B}{\sin A} - a^2 \frac{\sin C}{\sin A}$$

$$= a\,(b-c).$$

Simplifying the second and third fractions by the same method we obtain ab—ac+bc—ba+ca—cb=0.

III. *Solution by Norman Anning, Chilliwack, B. C.*

Lemmas:

$$(\sin X + \sin Y)(\sin X - \sin Y) = \sin (X+Y) \sin (X-Y). \qquad (1)$$

In any triangle,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = d. \qquad (2)$$

We have

$$\frac{a^2 \sin (B-C)}{\sin B + \sin C} = \frac{ad \sin A \sin (B-C)}{\sin B + \sin C}$$

$$= \frac{ad \sin (B+C) \sin (B-C)}{\sin B + \sin C}$$

$$= d\,(a \sin B - a \sin C).$$

Hence,

$$\frac{a^2 \sin (B-C)}{\sin B + \sin C} = d\,(a \sin B - a \sin C + b \sin C - b \sin A + c \sin A - c \sin B) = d \times 0 = 0.$$

IV. *Solution by W. W. Gorsline, Chicago.*

Given triangle ABC. Draw CC′=AC, assuming $a > b$. Then $\angle C'CB = A - B$. Let AC′=z and C′B=y.

$$\frac{\sin (A-B)}{y} = \frac{\sin B}{b}. \qquad (1)$$

$$\frac{\sin A}{\sin B} = \frac{a}{b}.$$

$$\frac{\sin A + \sin B}{\sin B} = \frac{a+b}{b}. \qquad (2)$$

$$(1) \div (2), \quad \frac{\sin (A-B)}{\sin A + \sin B} = \frac{y}{a+b}. \qquad (3)$$

In triangle AC′C, $z = 2b \cos A$,

$y = c - 2b \times \cos A$.

Sub. in (3), $\dfrac{\sin (A-B)}{\sin A + \sin B} = \dfrac{c - 2b \cos A}{a+b}$ but $a^2 - b^2 = c^2 - 2bc \cos A$ (4)

Mul. (3) by c, $$\frac{c^2 \sin (A-B)}{\sin A+\sin B}=\frac{(c^2-2bc\cos A)}{a+b}c=c(a-b) \quad (5)$$

Changing letters and adding, we have the required formula.

Algebra.

501. *Proposed by A. G. Montgomery, State Normal School, Athens, W. Va.*

Show that $x^{4m}+x^{2m}+1$ never represents a prime number if x be any other integer than one.

I. *Solution by R. M. Mathews, Riverside, California, and L. E. Mensenkamp, Freeport, Ill.*

$$x^{4m}+x^{2m}+1=(x^{2m}+1)^2-x^{2m}$$
$$=(x^{2m}+x^m+1)\,(x^{2m}-x^m+1)$$

This represents a prime only when one factor or the other is 1; this requires $x=0$ or 1 or -1. Therefore the number is composite for all other integral values of x.

II. *Remark by Murray J. Leventhal, New York City, Nelson L. Roray, Metuchen, N. J., H. H. Seidell, St. Louis, Mo.*

If $m=0$, the given expression $=3$ for all values of x. The condition that $m\neq 0$ should have been given.

502. *Proposed by Norman Anning, Chilliwack, B. C.*

Exhibit $(x^2+y^2+z^2)^3$ as the sum of three squares.

I. *Solution by the Proposer.*

Let $y^2+z^2=s^2$, $(x+is)^3=p+iq$. $(i^2+1=0)$.

Then $(x-is)^3=p-iq$,

and $(x^2+s^2)^3=p^2+q^2$,

$$=p^2+\frac{y^2+z^2}{s^2}q^2$$

$$(x^2+y^2+z^2)^3=p^2+\left(\frac{yq}{s}\right)^2+\left(\frac{zq}{s}\right)^2$$

Now

$$(x+is)^3=x^3+3ix^2s-3xs^2-is^3$$

$\therefore$

$$(x^2+y^2+z^2)^3=x^2(x^2-3y^2-3z^2)^2+y^2(3x^2-y^2-z^2)^2+z^2(3x^2-y^2-z^2)^2$$

Ex. $29^3=14^2+39^2+52^2=15^2+14^2+28^2=92^2+70^2+105^2$

II. *Each of the contributors, other than the proposer, whose names are found under "Credit For Solutions" sent in the following solution.*

$$(x^2+y^2+z^2)^3=(x^2+y^2+z^2)\,(x^2+y^2+z^2)^2$$
$$=x^2(x^2+y^2+z^2)^2+y^2(x^2+y^2+z^2)^2+z^2(x^2+y^2+z^2)^2$$

Geometry.

503. *Proposed by Clifford N. Mills, South Dakota State College, Brookings, S. Dak.*

The perpendicular from any point of a circle upon a chord is the mean proportional between the perpendiculars from the point upon the tangents drawn at the extremities of the chord. Prove.

I. *Solution by F. V. Rayl, Sioux Falls, S. D.*

Let P be any point and AB any chord of the given circle. Let PC be the perpendicular to AB, and PM and PN the perpendiculars to the tangents drawn at A and B, respectively.

To prove that PM : PC = PC : PN.

Proof:

Draw AP and BP.

Right triangles APM and APC are respectively similar to right

triangles BPC and BPN. (An acute angle of the one is equal to an acute angle of the other in each case).

$\therefore$ PM : PC = PA : PB and PC : PN = PA : PB.

$\therefore$ PM : PC = PC : PN.

II. *Solution by Sara Sankey, New Castle, Pa.*

Given the tangents AO and BO with the point P on the arc AB. Draw PC perpendicular to AB, PN perpendicular to BO, PM perpendicular to AO, also PA and PB.

$\triangle$APM is similar to $\triangle$BPC and $\triangle$APC is similar to $\triangle$BPN.

$\therefore$ Quadrilateral ACPM is similar to quadrilateral BNPC. (Composed of similar triangles, similarly placed).

$\therefore$ PN : PC = PC : PM.

III. *Solution by Murray J. Leventhal, New York City.*

(a) When the tangents meet.

[Solution similar to those above; omitted to save space.—Ed.]

(b) When the tangents are parallel.

PC is a perpendicular upon the diameter, AB, hence, a mean proportional between AC and CB. Obviously, PC is a mean proportional between PM and PN, since PM and PN are respectively equal to AC and CB.

504. *Proposed by Walker Cisler, student in West Chester, Pa., High School.*

To construct in a given circle seven equal regular hexagons, one having as its center the center of the given circle, and the other six erected on the sides of the first.

I. *Solution by John A. Marsh, Boston, Mass.*

Let the given circle have a radius, R. With any convenient radius, a, construct a regular hexagon and a second hexagon congruent to it, erected on one of its sides. Let b be the distance from the center of one of these hexagons to the further vertex of the other.

Form a fourth proportional, x, to b, a, and R, *i.e.*, $b:a = R:x$. Then x is the radius of the central hexagon in the circle of radius R, and the six congruent hexagons on its sides will each have two vertices on the circumference. The proof is obvious.

II. *Solution by Paul Baldwin, Evansville, Ind.*

Construction:

Produce a radius of the given circle to point P, at any convenient distance. From P draw a line to form an angle of 120° and make its length half the first line. Complete the triangle. At the intersection of the third line and the cricle, draw a line parallel to the second line. The segment of the fourth line intercepted by the first and third is a side of the hexagons.

Prove by means of: Radius = side, angle = 120°, similar triangles having proportional sides.

III. *Solution by H. H. Seidell, St. Louis, Mo.*

OA = R, radius of given circle.

Chord AC = r, radius of small circles and of the hexagons.

Let B be the middle point of AC. Then OB = three times apothem of hexagons.

$$OB = 3\left[\frac{r\sqrt{3}}{2}\right]$$

$$OA^2 = OB^2 + AB^2$$

$$R^2 = \frac{27}{4}r^2 + \frac{1}{4}r^2 = 7r^2.$$

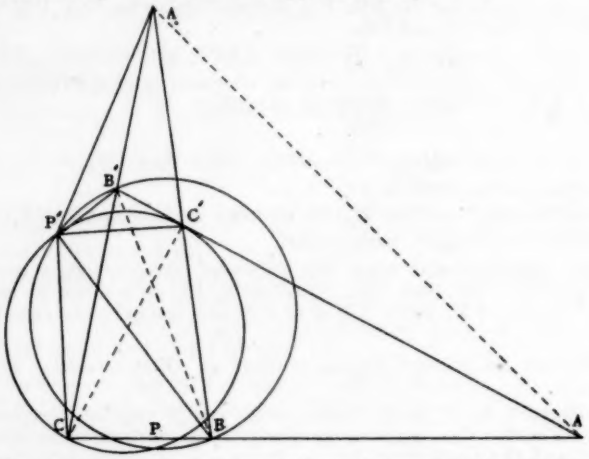
$$\therefore \sqrt{7} : 1 = R : r.$$

To find the radius of the hexagons find a mean proportional to $\sqrt{7}$, unity, and R.

505. *Proposed by R. T. McGregor, Bangor, Cal.*

Show that the circles described on the three diagonals of a complete quadrilateral as diameters are coaxial.

I. *Solution by Nelson L. Roray, Metuchen, N. J.*



Let the tetragram be constructed as above and the circles upon the diagonals CC′ and BB′ intersect at P′ and P.
Then $\angle CP'C' = \angle BP'B' =$ a right angle.
A′C′B′ is transversal of $\triangle ABC$

$$\therefore \frac{\sin A'P'B}{\sin A'P'C}\cdot\frac{\sin CP'B'}{\sin B'P'A}\cdot\frac{\sin AP'C'}{\sin BP'C'}=1 \qquad (A)$$

Also AC′B is transversal of $\triangle A'B'C$

$$\therefore \frac{\sin A'P'B}{\sin BP'C}\cdot\frac{\sin CP'A}{\sin B'P'A}\cdot\frac{\sin B'P'C'}{\sin C'P'A'}=1 \qquad (B)$$

(A) ÷ (B) gives

$$\frac{\sin BP'C}{\sin A'P'C}\cdot\frac{\sin CP'B'}{\sin CP'A}\cdot\frac{\sin C'P'A}{\sin C'P'B}\cdot\frac{\sin C'P'A}{\sin C'P'B'}=1 \qquad (C)$$

since $\angle CP'C' = \angle BP'B' =$ a right angle.
(C) is easily simplified to

$$\tan C'P'A \cdot \tan C'P'A' = 1$$

$\therefore \angle A'P'A =$ a right angle; also $\angle APA' =$ a right angle.
and it follows that the circles of the diagonals of a tetagram pass through the same two points P and P′. Since PP′ is a common chord of the three circles tangents from any point of the secant PP′ to the 3 circles are equal and the circles are coaxial.

CREDIT FOR SOLUTIONS.

495. Edward Fleischer. (1).

500. Charles H. Bartlett. (Other solutions credited in March issue). (1)

501. Earl G. Baird, M. Costello, Murray J. Leventhal, L. E. Mensenkamp, R. M. Mathews, Nelson L. Roray, Florence Pinney, M. G.

Schucker, H. H. Seidell, Horace D. Stellwagon, Dewitt T. Weaver, Edward Fleischer. (12)

502. Norman Anning, Earl G. Baird, M. Costello, R. M. Mathews, Evelyn H. Roberts (2), Nelson L. Roray, M. G. Schucker (2), H. H. Seidell, Horace D. Stellwagon, Dewitt T. Weaver. (12).

503. Earl G. Baird, Paul Baldwin, Charles H. Bartlett, C. W. Berner, C. E. Gates, Felix S. Hales, James S. Kassner, Murray J. Leventhal, R. M. Mathews, Charles T. Moore, F. V. Rayl, Nelson L. Roray, Sara Sankey, M. G. Schucker, H. H. Seidell, Dewitt T. Weaver, Edward Fleischer. (17).

504. Norman Anning, Paul Baldwin, Jeannette Bryce, Walker Cisler, John A. Marsh, R. M. Mathews, J. W. Ogg, Nelson L. Roray, Sara Sankey, M. G. Schucker, H. H. Seidell, Edward Fleischer (2). (13).

505. Murray J. Leventhal, Nelson L. Roray. (2).

58 solutions.

A Request.

We respectfully request that all contributors read and heed the following rules:

1. Introduce each solution submitted as follows: 999. Solution by (*Your name and address*). It is not necessary to copy the words of the problem. The number is sufficient.
2. Write only on one side of the paper.
3. If two or more short solutions are written on the same page, leave ample space between problems and don't fail to observe Rule 1.
4. Do not make solution dependent on a submitted figure, e.g., do not write "line AB" with no previous verbal definition of A and B, expecting a reader to find the line and points on a figure. It is not always convenient to publish the figure.
5. Where a figure is necessary, draw the same accurately and to scale on a separate sheet of paper in jet black or India ink.
6. Introduce each problem proposed as follows: Proposed by (*Your name and address*). When more than one proposed problem is written on a page, leave ample space between problems that they may be clipped.

PROBLEMS FOR SOLUTION.

Algebra.

516. *Proposed by Daniel Kreth, Wellman, Ia.*

An estate was divided among A, B, and C in the following manner: A received a dollars and one n-th of the remainder; B received $2a$ dollars and one n-th of what remained after A's share and $2a$ dollars had been deducted; C received $3a$ dollars and one n-th of what remained after the shares of A and B and $3a$ dollars had been subtracted. By this arrangement there was nothing left. What was the value of the estate?

517. *Proposed by N. P. Pandya, Khatri Pole, Bajwada, Baroda, India.*

Factor $x^{2n}-x^ny^n+y^{2n}$, n being odd.

Geometry.

518. *Proposed by George Blanchard, Portland, Ore.*

Given one angle of a triangle and the sum of an adjacent and opposite side and the radius of the inscribed circle, to construct the triangle. (From *Nixon's Euclid*).

519. *Proposed by R. T. McGregor, Nord, Cal.*

A and B are two fixed points and a variable circle through them cut, a fixed circle in C and D. Show that the line joining the intersection of AC, BD and AD, BC passes through a fixed point.

Trigonometry.

520. *Proposed by Clifford N. Mills, Brookings, S. D.*

If the sines of the angles of a triangle be in arithmetical progressions the product of the tangents of half the greatest and half the least angle is $\frac{1}{3}$.

News Note.

The name of Norman Anning must certainly be familiar to every contributor to this department. He has been solving problems for this department for more years than its present editor has known of SCHOOL SCIENCE AND MATHEMATICS. Therefore, we feel sure that the item of news contained in the following letter received from him at the time he sent the solution to problem 502 will be of interest to every reader. We extend our sincerest wishes for his safe return and hope to receive further solutions from him in the future.—Editor.

Chilliwack, B. C., Jan. 25, 1917.

Dear Dr. Hassler:

I intend to join His Majesty's overseas forces in a few days. So my future contributions will likely be irregular. Mrs. Anning will save my magazines that I may try to catch up to your advancing chariot when peace is assured. With best wishes, I am

Yours sincerely,

NORMAN ANNING.

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your first term or mid-year examination papers now*

Acknowledgment.

The receipt of examination questions is gratefully acknowledged from Clifton B. Holt, Clark University, South Atlanta, Ga., and Annie Cloyd, Sewickley, Pa.

Questions and Problems for Solution.

259. *Proposed by Annie Cloyd, Sewickley, Pa.*

Cannot something be done to avoid the repetition that high school students who have had preparatory chemistry are required to make in their first year college work?

260. *Proposed by C. T. Beach, Tunkhannock, Pa.*

In the case of a boy rowing a boat, what class of lever do we have represented?

261. *Proposed by H. A. Porter, Pearsall, Tex.*

A few short articles on the *electron theory of valence* have appeared in SCHOOL SCIENCE AND MATHEMATICS, and I believe the readers would be interested in a more lengthy discussion of this theory, dealing with specific oxidation and reduction equations. I am interested in the equations that follow.

(1) Which oxid of nitrogen is set free, NO or NO_2?

$$Sn + H\,NO_3 \text{ (concentrate)} \rightarrow H_2SnO_3 + \text{———} + \text{———}$$

(2) $$Zn + H_2SO_4 \text{ (concentrate)} \rightarrow SO_2 + \text{———} + \text{———} + \text{———}$$

262. *Proposed by H. A. Porter, Pearsall, Texas.*

Are equations (3) and (4) correct? [electron = $\ominus$]

(3) $$H_2S^{6+}O_4 + 8\ominus + 8H^+ \text{ (concentrate)} \rightarrow H_2S^{2}\downarrow + 4H_2O \quad \text{Extra acid, 4 molecules}$$

(4) $$4Zn^0 \rightarrow 4Zn^{2}\downarrow + 8\ominus$$

Please answer questions numbered 263, 264, and 265 from the following paper:

COLLEGE EXAMINATION BOARD COMPREHENSIVE EXAMINATION IN PHYSICS, MONDAY, SEPTEMBER 18, 1916, 2:00–5:00 P. M.

Answer ten questions. Show clearly the method by which you obtain your answers, and state the units used in each case.

1. (*a*) Define kinetic energy; potential energy.

263. A shell weighing 6 lbs. fired from an anti-aircraft gun aimed vertically upward has a muzzle velocity of 1,200 ft. per sec. If the shell bursts beside an aeroplane 3 sec. after leaving the gun, how high is the aeroplane?

264. A boy weighing 110 pounds sits in a hammock whose ropes make angles of 60^0 and 30^0 respectively with the horizontal. Find the tension in each rope.

3. (*a*) Draw a diagram of a force pump. Explain the action of the pump, referring as much as possible to your diagram in giving your explanation.

265. A 1.5 horse-power gasoline engine is used to drive a force pump which pumps water from a spring to a 60-gallon tank 70 ft. higher than the spring. If the tank is filled in 2 minutes, what is the efficiency of the pump? (A gallon of water weighs 8.4 lbs.)

4. A bubble has a volume of 5 c.c. and is at a depth of 1 meter below the surface of water, the barometer reading 70 cm. of mercury. If the barometric pressure changes to 73 cm., what will be the resulting volume of the bubble? (Specific gravity of mercury = 13.6.)

5. Explain the action of a megaphone. Give a physical explanation of the reason that sound can be transmitted to greater distances through a speaking-tube than in the open. Why does the presence of a large number of people in an auditorium improve its acoustic properties, that is, make it easier to understand the speaker?

6. (*a*) The sound of a fire-alarm is heard 3 sec. after the bell is struck by the hammer. If the temperature of the air is at 68^0F., how far away is the bell?

(*b*) If the *A* above middle *C*, tuned to 435 vibrations per second, is the standard pitch for the orchestra, what is the vibration frequency of middle *C* upon the same scale?

7. What determines the magnitude of (*a*) 1^0 C.? (*b*) 1^0 F.? In what respects would a gas thermometer be (*a*) superior and (*b*) disadvantageous as compared with a mercury, or liquid thermometer? Explain.

8. How many grams of steam will be produced if 1,000 gm. of lead of specific heat 0.032 at a temperature of 300^0 C. are dropped into 100 gm. of water at 80^0 C. contained in a calorimeter of specific heat 0.1 and weight 90 gm.?

9. Why does hot air rise? Why does frost appear on the inside of a window pane in one's living-room before it appears on the outside of the pane? Why are hot-air registers placed near the ceiling and cold-air registers placed near the floor in mechanically ventilated schoolrooms? What is the cause of the loud hammering heard in certain steam radiators in the early morning, and how may the trouble be remedied? Why are furnace pipes placed near the inner walls of a room heated by hot air, and why are steam radiators placed near the outside walls of a room heated by steam?

10. Describe a laboratory experiment that you performed in which you used some form of mirror, either plane or curved. Do this very completely, drawing diagrams whenever possible. State not only what you did but also what you found to be true as the results of your experiment.

11. A camera with a lens whose principal focal distance is 4 in. permits the lens to be drawn out to a maximum distance of 5 in. from the plate.

(*a*) What is the shortest distance from the lens at which a flat object may be placed in order to secure a properly focussed image?

(*b*) If the object is 8 in. high, what will be the height of its image?

12. Why does one's face appear so ghastly and one's lips so purple when seen by the light of a mercury-vapor arc lamp? Would the addition of a colored shade to the lamp improve the situation? Explain.

13. Describe an experiment that you performed in the laboratory in which a voltmeter or ammeter or some form of galvanometer was one of the pieces of apparatus used. Draw diagrams where helpful, and state, not only what you did, but also the object of the experiment.

14. (*a*) A battery, whose e.m.f. when delivering no current is 2 volts and whose internal resistance is 6 ohms, sends a current of ¼ ampere through an external resistance connected across its terminals. Find the value of the external resistance.

(*b*) How many watts are supplied to the external resistance?

15. (*a*) Explain clearly what is meant by an alternating current.

(*b*) What are the advantages and disadvantages of an alternating current as compared with a direct current?

Solutions and Answers.

236, 237. *Also solved by Clifton B. Holt, Clark University, South Atlanta, Georgia.*

244. *Proposed by W. A. Hedrick, Washington, D. C.*

Several answers have been received, *all different.* It looks to the Editor as though Dr. Hedrick was trying to start an argument. The Editor can not see how the apparatus in 244(b) and (c) can be set up with a *moveable* pulley as specified. Differences will be harmonized by correspondence and results printed probably in May.

247. *Also solved by C. B. Holt, C. T. Beach, and Marion Storrs.*

248. *From College Board Comprehensive Chemistry, September, 1916.*

Write a reversible chemical reaction, and explain how it may be made to go to completion in either direction.

Answer by Marion Storrs, Thompsonville, Conn.

$$2\ NaHSO_4 \text{ strongly heated} \rightarrow Na_2S_2O_7 + H_2O$$
$$Na_2S_2O_7 + H_2O \text{ (dissolved in)} \rightarrow 2NaHSO_4$$

Answer by C. T. Beach, Tunkhannock, Pa.

$$CuO + H_2 \rightleftarrows Cu + H_2O$$

If hydrogen is passed over heated copper oxide and the water vapor driven off as soon as it is formed, it will go to completion toward the right.

If steam is passed over heated copper and the hydrogen removed as soon as formed, the reaction will go to completion toward the left.

If the reaction is carried on within a closed tube and neither volatile product is allowed to escape, the reaction will not go to an end, and we have a case of dynamic equilibrium.

Answer submitted by Clifton B. Holt, Clark University, South Atlanta, Ga.

One of my students, Chandos Maxey, answered as follows:

$$Fe + H_2O \rightleftarrows FeO + H_2$$

"The reversible action" [equilibrium] "may be broken up by adding more iron or letting the H pass off." Not a very complete answer, but one that shows a little understanding of the problem.

250. *From "Chemical Calculations" (Van Nostrand) by R. Harman Ashley, Ph. D.*

If the volume of the moon is $\frac{1}{49}$th and its mass $\frac{1}{81}$st that of the earth, (*a*) what is the density of the moon compared to the earth? (*b*) If the relative density of the earth is 5.53, what is the relative density of the moon? *Ans.* (*a*) 0.605; (*b*) 3.34.

Solution by R. T. McGregor, Nord, Cal.

Since density equals mass ÷ volume the density of the moon compared with that of the earth equals $\frac{1}{81} \div \frac{1}{49} = .6049$. If the density of the earth is 5.53, the density of the moon equals $.6049 \times 5.53 = 3.345$.

251. The question has been asked the Editor—"Why are not Botany examinations printed in this department?" In answer is given the following Botany examination:

What would Botany teachers like to see in these columns?

Comment by Annie Cloyd, Sewickley, Pa.

The botany examination from Brown University seemed to me almost too easy.

[No other comments were received. Are not Botany teachers interested? EDITOR.]

252. *From an entrance examination of Mass. Inst. Tech., Sept., 1916.*

A plank 20 feet long, weighing 200 pounds, rests on a flat roof with 8 feet of its length projecting beyond the edge of the roof. If a keg of nails weighing 100 pounds rests on the inner end, how far out on the plank may a man weighing 180 pounds go without tipping?

Solution by Benjamin H. Timm, Scio, New York. Also solved by C. B. Holt, S. Atlanta, Ga., Annie Cloyd, Sewickley, Pa., R. T. McGregor, Nord, Cal.

To begin with, I think the question is misleading, unless my solution is wrong, for the answer would cause a student to imagine his work incorrect.

The problem comes under parallel forces acting on a lever. The fulcrum is at the point where the plank rests on the edge of the building, the center of gravity of the plank is two feet from this point and over the building. With the keg of nails at the extreme end of the plank over the building, the moment which tends to keep the plank down to the building is $12 \times 100 + 2 \times 200$, or 1600. Dividing this moment by 180, we get 8.8+ feet to which a man weighing 180 pounds could go on the plank before tipping if the plank were that long; or in other words, it would be safe for him to go to the end of the plank without fear of tipping it.

253. *From a Mass. Inst. of Tech. Physics exam., Sept., 1916.*

How far from a screen must a 100 candle power lamp be placed to give the same illumination on the screen that a 40 candle power lamp 5 feet away would give?

Solution by Annie Cloyd, Sewickley, Pa. Also solved by R. T. McGregor, Nord, Cal.

Equal illumination varies directly as the square of distance.

$$X^2 : 5^2 :: 100 : 40.$$
$$40X^2 = 2500.$$
$$X_2 = 62.5$$

$X = \pm 7.9$ ft., distance where equal illumination would be obtained.

DEPARTMENT OF MATHEMATICS QUESTIONS AND ANSWERS.

Conducted by Herbert E. Cobb,

Lewis Institute, Chicago.

For the many mathematics teachers who are entering the profession every year, and for those who after some years of work and study find themselves at times in doubt concerning questions of subject matter, methods, devices to interest pupils, the history, psychology, or bibliography of mathematics, special problems and the like, this department is established. Probably the question that is perplexing some teacher at the present time has been faced and successfully answered by many others.

It is hoped that many will make use of this opportunity, not only to send in questions, but also to furnish replies to questions already published. Brief discussions, from two hundred to three hundred words, of points brought out in the questions will be appreciated. One or two answers to a question are not to be considered final. Several answers from different viewpoints are desired. Address all communications to H. E. Cobb, Lewis Institute, Chicago.

Answers.

1. What is the most effective way of using the blackboard during a recitation in geometry?

Answer by Montana Rice, Palmyra, Mo.

The method of using the blackboard during a recitation in geometry should vary with the nature of assignment. One student may write the

proof on the board as it is given, step by step, by the different members of the class. If an original problem is being worked out by the class for the first time, a student may write an outline of the proof, or solution as the class work it out, the teacher permitting a challenge of the truth or of the choice of any statement before proceeding to the next. While a number of volunteers write either the outline or the proof in full on the board, the teacher may discuss with other members difficult points. This last plan enables the teacher to get in touch with the slower thinkers. If problems of construction are assigned, a number of students may work at the board at the same time, using rulers, compasses and other apparatus. For review work, typewritten questions may be distributed, each student receiving a different question. The students then pass to the board, draw figures and each writes at least a part of proof, preparatory to an oral discussion of his question.

3. How much attention should be paid to the check in the solution of equations?

Answer by Albert Earley, North Plainfield, N. J.

The habit of continually checking his work is one of the most valuable habits that a student can form. It is a great source of satisfaction to know that he is right without the necessity of referring to the answer book. When the boy leaves school and solves real problems he will not have an answer book, and in many cases it is absolutely essential that he be right. If he is a bridge engineer a mistake may cost his reputation, thousands of dollars, and many lives.

When the author studied co-planar statics we were taught to solve all problems in two ways so that one method would be a check on the other. The engineer continually checks his work by the slide rule, planimeter, graphical methods, and the compasses. The place to acquire this habit is the school. While I do not say that every equation should be checked the student should practice it sufficiently to know the value of it and to have greater confidence in his results.

Question.

7. In what way can I best help pupils to overcome the difficulty they have in stating the conditions of a problem in the form of equations?

CHANGES IN STRUCTURE OF BRONZE THROUGH ANNEALING.

A study has just been completed by the Bureau of Standards, Department of Commerce, of the annealing of bronze, using the commercially important alloy, zinc-bronze (copper 88, tin 10, zinc 2) as a type and the results published in Technologic Paper No. 60, just issued.

The properties of cast steel may be greatly improved by refining the grain by proper annealing. The changes occurring in cast brasses and bronzes upon annealing are by many metal workers regarded in the same light. The results of the Bureau's study show that bronze is very different in its behavior from steel and shows no recrystallization or "grain-refining" unless it has been previously cold worked as by rolling or hammering.

Copies of the publication, entitled "Microstructural Changes Accompanying the Annealing of Cast Bronze," may be obtained without charge from the Bureau of Standards, Washington, D. C.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

PHOSPHORESCENCE.

One of the most interesting cases of the emission of light is that which occurs from certain substances at the ordinary temperatures of the room when they are excited by the proper stimuli. If the light is visible only so long as the excitation lasts the phenomenon is known as "fluorescence," but if the light lasts for an appreciable length of time after the cessation of the excitation the term "phosphorescence" is used. The most familiar example of the latter is luminous paint the basis of which is calcium sulphide. This paint will glow in the dark many hours after being exposed to strong light.

Many substances exhibit phosphorescence. There are to be found on the market series of test tubes which if exposed for a few seconds to the light of an arc lamp will after removal glow strongly, giving out light of various colors. A characteristic feature of nearly all substances that phosphoresce to a marked extent is that they contain sulphur. They are in fact solid solutions of sulphides and are made by taking a large quantity of one substance and adding to it a very small quantity of another. The mixture is dissolved and precipitated, thus yielding a very intimate mixture of the two ingredients, which gives results not to be obtained from mere mechanical admixtures of one component with the other. Some complex substance which is peculiarly susceptible to light appears to result from the mutual interaction of the two ingredients.

Still another feature is that the brightest light is given off by substances containing metals of high valencies such as III or IV, which can therefore give rise to compounds of different types. Certain other conditions must be fulfilled. For instance, there must be greedy absorption of light to supply the requisite energy and this light must be derived from the neighborhood of an absorption band.

According to Sir Joseph Thomson[1] the energy corresponding to the absorption goes to produce within the mixture some kind of chemical change by which certain complex compounds are transformed into a different and less stable type. The latter naturally tend to go back to their original form, but reversion proceeds slowly, and is accompanied by the phosphorescence. Professor Thomson calls attention to the fact that it is known that the action of light on a substance tends to make it give out negative particles. Hence it might be supposed that the effect of the light absorbed by the substance is to take from one of the compounds present a negative particle. This electron would naturally try to settle on any electro-negative element present, such as sulphur. There the expelled particle would find a temporary home and as it returned to its original resting place the particle would become a source of light. If the reversion took place rapidly the action would be accompanied by fluorescence; if slowly, by phosphorescence.

Therefore, the complete process would consist in the first place of a

[1] This article is based on one of Professor Thomson's lectures at the Royal Institution.

storage of energy, due to the action of the light in causing negative particles to shoot out from the substances acted on, the necessary energy being supplied by the absorbed light. In the second place these particles would lodge in their temporary resting places, their position in regard to their original location being analogous to that of a stone raised high above the earth. Finally the particle falls back to its original position, giving up its energy, which is then radiated as luminous vibrations.

Some such explanation is necessary in order to form any idea of the nature of phosphorescence. If the action is to be looked upon in this way one might expect that a certain amount of control might be exercised over the action. As a matter of fact such is the case. By the action of extreme cold it is possible to suspend indefinitely the transformation into phosphorescence of the potential energy due to the displaced electrons. If after excitation the phosphorescent body is exposed to the temperature of liquid air the action will be stopped. Light can thus, as it were, be "put into cold storage" since the substance on warming up again, will show the normal phosphorescence.

With some bodies, however, the return of the displaced particles is so quick that it is impossible to delay their return by the action of the cold. By keeping these bodies in liquid air during the process of excitation, the return can, however, be made slow enough for the bodies to phosphoresce visibly. Examples of such substance are the ordinary paraffin candle and an egg-shell.

In the foregoing cases the phosphorescence is stopped by extreme cold. In contrast to this there exists the phenomenon of thermo-luminescence exhibited by certain solid solutions in which the new condition is so stable and the return so slow that with ordinary conditions no visible light is produced. The return can however be accelerated by heating the body, in which case the energy is liberated at a rate sufficient to affect the eye. In such cases the new substance formed by the action of the rays is so stable that the chemical reversion is not rapid enough to yield light unless it is accelerated by increase of temperature.

Phosphorescence can be produced not only by light but also by other means of excitation, although it is probable that the mechanism is similar in all. Phosphorescence can be produced by simply bombarding a substance with cathode rays, in which case the negative particles of the cathode discharge are driven right into the substance and there give up their energy. This effect may be shown with powdered Iceland spar, which will continue to glow with an orange colored light long after the bombardment has ceased.

Still other sources of excitation may be used. A very striking example is that of the phosphorescence produced in a bulb containing pure oxygen at a low pressure. If such a bulb is inserted in a coil through which an alternating current is passing it forms a secondary to the coil and a current is produced in the gas itself. This luminosity will continue for an appreciable time after the bulb is removed from the exciting coil. This phenomenon, according to Professor Thomson, arises because the excitation produces a modification of the oxygen, which gradually reverts to its original state when the bulb is removed and while doing so gives out light. A similar glow can be obtained with pure nitrogen. As a rule, however, fluorescence is more common in the case of gases and also of liquids, but the difference is one of degree and not of kind.

In conclusion two of the more important characteristics of luminescence of this kind should be mentioned. One is the law of Stokes which states that the light given out is always of a greater wave length than the exciting light. The other is that the spectrum of the light given out by a substance reveals bands and lines characteristic of the elements involved.

The explanation of the general nature of the action which has been given, although very suggestive, does not of course give any very definite idea of the actual mechanism by which the atom is able to absorb energy from sources as diverse as electromagnetic waves and streams of electrons, transform it into potential energy, and then later permit it to dissipate itself gradually in the form of light waves characteristic of the atoms themselves. As a matter of fact phenomena of this kind have received the most careful study, and the results of the investigations, while not explaining the ultimate nature of the mechanism, have contributed conspicuously to the development of the modern theory of radiation.

THE MAGNITUDE OF THE ELECTRIC DISCHARGE IN LIGHTNING FLASHES.

The sign and magnitude of the electric charges transferred from the atmosphere to the earth in lightning flashes are of interest, not only in themselves, but also as having to be taken into account in any attempt to test whether there is a balance in the interchange of electrical charges between the atmosphere and the surface of the earth. Mr. C. T. R. Wilson, Observer in Meteorological Physics at the Solar Physics Observatory, Cambridge, has made some very important investigations of such phenomena.

As it was hardly possible to use systematically a direct method for the measurement of lightning discharges, the most promising method seemed to be that of making absolute measurements of the sudden changes produced in the vertical electric field of the atmosphere at a given point of the earth's surface by lightning discharges in the neighborhood. A measurement of the difference between the vertical electric force immediately before and immediately after the flash at a sufficient number of points would give a measure of the current.

It is impracticable to carry out this method completely, but an approximation to it may be made by measuring the changes of field at a point due to lightning discharge. When a lightning flash passes between the earth and the cloud, the charge on the cloud and the corresponding induced charge on the earth are destroyed and the vertical electric field due to them disappears. Thus there will be a change in the vertical force at the time of a flash, and the magnitude and sign of this change will be a measure of the quantity of electric charge involved in the flash and the direction of the current.

The apparatus consists essentially of a flat conductor whose upper surface is on the same level as the surrounding ground which is supported on insulators but connected to earth through a capillary electrometer. By means of this arrangement the surface density of the charge on the ground can be measured, and also any sudden change in the surface density produced by the lightning. The vertical force is proportional to the surface density, and from its change the magnitude of the charge transferred by the flash can be computed.

The fullest observations were made in storms of which the prevailing direction of the electric currents was upwards. This may be interpreted as indicating that the falling rain drops of the thunder cloud were positively charged, leaving behind them a negative charge on the upper part of the cloud. The lightning discharges were, therefore, actually tending to neutralize the electric field produced by the falling of the charged rain drops to the earth.

The best determinations indicated that 30 coulombs was a characteristic value of the quantity of charge associated with a flash of lightning. It is interesting to compare this with the amount of electricity flowing from the atmosphere to the earth as a result of the normal potential gradient

and atmospheric ionization. The indications are that this current, if summed up over the surface of the earth, would be of the order of 1,000 amperes. Thus about thirty-three flashes per second would be required to neutralize the total current. As the effect of the lightning is undoubtedly largely a matter of neutralizing the currents due to precipitation, the effect of thunder storms in increasing or decreasing the atmospheric charge is probably very small.

The Crushing of a Copper Tube by Lightning.

Very interesting evidence concerning the current strength of a lightning discharge is furnished by a case of the crushing of a copper lightning rod described by Professor W. J. Humphreys.[2]

The rod was originally in the form of a copper tube of 16 mm. external and 14.65 mm. internal diameter. Under the action of the lightning discharge it was completely crushed and opened at the brazed joint.

It seems altogether probable that the collapse of the tube was a result of the "pinch" effect of the current. Each longitudinal fibre, as it were, of the conductor attracted every other fibre through the interaction of the magnetic fields due to their respective currents, and the resulting magnetic squeeze on the hollow rod, whose walls were weakened by the heating of the current, caused it to collapse.

It is not known just how much pressure would be required to cause the collapse of such a tube, but if it is assumed that a pressure of at least an atmosphere would be necessary then the approximate value of the corresponding current would be 20,000 amperes. As a matter of fact this is probably a minimum value of the current, for other considerations lead to a much higher figure.

From the probable length of time of the discharge and the heat produced, an idea of the magnitude of the current can also be gained. From an examination of the available data it is estimated that the duration of a complete discharge, that is, the sum of the times of the several components, may occasionally amount to at least 0.01 second. The highest temperature to which the copper tube was raised is indicated by the fact that the brazed joint was opened and most of the solder removed, and the further fact that the condition of the rod itself in several places indicated incipient fusion. If so the rod must have been heated to about 1,050° C. Computing the heat capacity of the rod from its specific heat, its density and its dimensions and assuming the duration of the flash to have been 0.01 second, the author finds that the current must have been in the neighborhood of 90,000 amperes. If this figure is correct the pressure on the tube must have been nearly 400 pounds per square inch; enough, presumably, to produce the crushing that actually occurred.

A current of 90,000 amperes for 0.01 second would mean 900 coulombs, which is a quantity much greater than that indicated by the investigations referred to in the article above. Such a quantity of electricity is enormous in comparison with the charges which can be isolated in a laboratory. On the other hand it would electrolyze only 0.084 of a gram of water, and from this standpoint is rather small.

New Microbalance.

We are sometimes interested in knowing how accurate very fine measurements are from the standpoint of percentage. We are also curious to know how the smallest quantities that can be detected compare in magnitude with the quantities of ordinary experience. Comparison of masses has always appealed to the imagination from both standpoints. Not only can measurements of mass be made with extreme accuracy,

[2] *Monthly Weather Review*, 43, 396, 1915.

but very small masses can be measured by direct means. Recently there has been described an improvement on the torsion balance of Nernst. A quartz thread of .00125 cm. diameter is stretched between the prongs of a brass fork of 9 cm. span. To this thread is fastened the beam, a glass capillary 13 cm. in length, the load arm having a length of 10 cm. The balance is sensitive to 3.3×10^{-8} gm., with a maximum load of 5 mgm.

An Experimental Demonstration of the Inertia of Electrons.

The modern theories of electricity have led to the belief that the passage of an electric current through a metal really consists in the progressive motion of "free" electrons contained in the body of the metal itself. If this be true, we may now expect a number of effects arising from the *mass* of these electrons which were not predictable on the older theories which thought of electricity as a sort of intangible massless fluid. As examples of such effects, we should expect the rear end of an accelerated rod of metal to become negatively charged owing to the lagging behind of the relatively mobile electrons which the metal contains, and should expect the periphery of a rotating disc to become negatively charged owing to the action of centrifugal force on the electrons in the disc. Such effects, however, would presumably be very small, owing to the exceedingly small mass probably associated with the electron.

In the case of electrolytes, effects such as these have long been known, their experimental determination being far less difficult than with metals, owing to the relatively large masses associated with the carriers of electricity in such conductors. An effect of this kind by the acceleration method was first obtained by Colley in 1882. A tube containing a solution of cadmium iodide and provided with electrodes at the two ends was given a sudden negative acceleration by dropping it and then bringing it to rest in a box of sand, the small pulse of electricity being measured by a galvanometer. More elaborate experiments have since been carried out by Tolman, both by the acceleration and the centrifugal method.

Many investigations have been made to determine a similar effect in the case of metals. The most successful attempts have been those of Tolman and Stewart (*Phys. Rev.*, 8, 97, 1916). A coil of wire is rapidly rotated and then suddenly stopped. This produces a deflection of a galvanometer connected in series with the coil. The throws obtained were always in the direction predicted on the basis of mobile electrons with a negative charge. In spite of the very difficult experimental conditions, quantitative determinations were made which are in good accord with the mass of the electron in free space.

The Amount of Heat from the Sun and Sky.

The maximum daily amount of radiation received on a sq. cm. of horizontal surface at Madison, Wis., varies from 220 calories in December to 770 calories in June. The corresponding mean daily amounts are 130 and 530 calories. The quantities for June are very similar to the amounts obtained at Washington, but in winter the Washington values are higher, as might be expected from the difference in latitude of the two places.

THE HALF-ANGLE FORMULAS DERIVED BY LINE VALUES.

By G. N. Armstrong.
Ohio Wesleyan University, Delaware, Ohio.

The half-angle trigonometric formulas developed geometrically by Mr. A. Babbitt in the January number are readily obtained by use of the "line representatives" of the functions.

Let O be the center of the unit circle, XX′ and YY′ the horizontal and vertical diameter, respectively, $\angle XOA \angle \alpha$ ($<90^0$), and $AB \perp XX'$ from A, A on the circle and B on the horizontal diameter.

Then OB represents $\cos\alpha$, BA $\sin\alpha$, and, in the right triangle BX′A, $X'A = \sqrt{(1+\cos\alpha)^2+\sin^2\alpha} = \sqrt{1+2\cos\alpha+(\cos^2\alpha+\sin^2\alpha)} = \sqrt{2(1+\cos\alpha)}$

Similarly, in triangle BAX, $AX = \sqrt{2(1-\cos\alpha)}$

Then, from triangle BX′A,

$$\sin\frac{\alpha}{2} = \frac{BA}{X'A} = \frac{\sin\alpha}{\sqrt{2(1+\cos\alpha)}} = \sqrt{\frac{1-\cos^2\alpha}{2(1+\cos\alpha)}} = \sqrt{\frac{1-\cos\alpha}{2}}$$

$$\cos\frac{\alpha}{2} = \frac{1+\cos\alpha}{\sqrt{2(1+\cos\alpha)}} = \sqrt{\frac{(1+\cos\alpha)^2}{2(1+\cos\alpha)}} = \sqrt{\frac{1+\cos\alpha}{2}}$$

$$\text{and } \tan\frac{\alpha}{2} = \frac{\sin\alpha}{1+\cos\alpha}$$

Likewise, from triangle BAX.

$$\sin\frac{\alpha}{2} = \frac{1-\cos\alpha}{\sqrt{2(1-\cos\alpha)}} = \sqrt{\frac{(1-\cos\alpha)^2}{2(1-\cos\alpha)}} = \sqrt{\frac{1-\cos\alpha}{\sqrt{2}}}$$

$$\cos\frac{\alpha}{2} = \frac{\sin\alpha}{\sqrt{2(1-\cos\alpha)}} = \sqrt{\frac{1-\cos^2\alpha}{\sqrt{2(1-\cos\alpha)}}} = \sqrt{\frac{1+\cos\alpha}{\sqrt{2}}}$$

$$\tan\frac{\alpha}{2} = \frac{1-\cos\alpha}{\sin\alpha}$$

The method clearly holds for $\alpha > 90^0$.

My experience has been that this way of showing these relations appeals more strongly to the student than the analytical ones of the textbooks. I am a firm believer in a liberal use of the "line representatives" of the functions in teaching trigonometry, after the ratio definitions have been thoroughly mastered.

A CHECK IN ADDITION.

By E. Lunn.
Heron Lake.

We frequently find in our elementary algebra a problem such as this. The sum of the digits in a certain number of two figures is seven and if the digits be interchanged the value of the number is decreased by 27. Find the digits.

It has been my experience that teachers of algebra feel that they have done their entire duty when the class has learned to solve this problem. There is an interesting sidelight that may be thrown on this problem, without any particular expenditure of time, relating to the rule for finding error in a trial balance.

Among other suggestions for finding error in a trial balance is this. Divide the error by nine and if this is an exact division the error may be due to transposing the figures in some number, e. g., writing 45 as 54.

The reason for this rule is very apparent in the solution if the student's attention is only called to it. Let us take up the solution of the above problem.

Let d be the unit's digit in the first number, and D be the ten's digit in the first number.

Then the first number is of the form $10D+d$; also if the digits be interchanged the second number is of the form $10d+D$.

Proceeding to take the difference of the first and second numbers we have; $9D-9d$. This difference is divisible by 9 and consequently the error introduced in any addition by the interchange of digits in one of the numbers is always a multiple of nine.

LIQUID MEASURING PUMPS.

The Bureau of Standards, Department of Commerce, has recently published a report, *Technologic Paper, No. 81*, pertaining to the accuracy of liquid measuring pumps commonly used in dispensing gasoline.

The development of the cheap motor car, resulting in a phenomenal increase in the number of cars in use, has brought about a steady increase in the quantity of gasoline consumed, and this, together with the present high price of gasoline, makes the method and accuracy of the retail dispensing of gasoline a question of the highest importance.

On account of the convenience of the measuring pump in delivering gasoline to the consumer with a minimum of evaporation, spillage, and fire hazard, by far the greater part of this commodity is sold through this type of measuring apparatus.

There are several types of measuring systems in use in this country, the most common being the piston type, in principle the same as the ordinary plunger pump, equipped with stops to define the volume discharged. Other familiar types of gasoline measuring apparatus are: second, the meter type, in which the gasoline is discharged through a meter by displacement of the oil over water, or by pneumatic pressure, or by mechanical pumping; third, the overflow measuring chamber type, in which an excess over nominal delivery is supplied to a visible measuring chamber and the excess removed by air pressure or other means to a definite level; fourth, the gauge glass, or float gauge type, in which the amount of liquid drawn off is read on a transparent gauge glass or by a float traversing a scale graduated in suitable units.

The principal causes of short delivery are leaks in valves or piping; formation of vapor due to excessive suction lift, or the introduction of air under the piston; failure to correct for the inertia of a long column of moving liquid; the use of long filling hoses with a low connection at the pump, making proper draining of hose an impossibility; "short stroking" or operation of pump at less than full stroke (usually deliberate); and slippage past valves and piston.

A proper routine for inspectors to use in testing measuring pumps, as well as the requisites for sealing and the manner of keeping detailed records, are completely described in the full paper.

Since this paper was written, subsequent tests in many cities corroborate the figures given above in every essential, and it is safe to say that in all localities not under an efficient and competent weights and measures

administration, and in a large majority of those which do have a relatively competent weights and measures administration, the condition of measuring pumps is such that the motoring public is being subjected to regular and continuous shortages in its purchases of gasoline. Figures based on the best estimates obtainable show that in the state of Illinois, the losses to the people of the commonwealth, due to short measures in gasoline, are not less than $530,000 annually.

Copies of this paper may be obtained by applying to the Bureau of Standards, Washington, D. C.

WYOMING GYPSUM BEDS EXAMINED BY GOVERNMENT GEOLOGISTS.

It has long been known that the state of Wyoming possesses enormous gypsum deposits, which are found in red beds that are widely distributed over the central part of the state. The scarcity of timber in certain areas is gradually leading to the extensive use of gypsum in the manufacture of building blocks, and for this reason detailed information concerning the deposits is desirable.

The east and the west slopes of the Bighorn Mountains and the southeastern part of the Bighorn Basin are especially rich in gypsum deposits suitable for exploitation. Government geologists have examined many of the deposits, and the results of their examination are set forth in a report just issued by the United States Geological Survey, Department of the Interior, as *Bulletin* 640-*H*, by Charles T. Lupton and D. Dale Condit. Anyone interested in the subject may obtain a copy of the report on application to the Director, U. S. Geological Survey, Washington.

THE GEOLOGY OF PETROLEUM.

The far-reaching importance to the United States of an adequate supply of petroleum and gasoline has long been recognized by the United States Geological Survey, which during the last two years has made greater efforts than ever before to assist in discovering and in developing new oil reserves. Brief accounts of the work accomplished, with titles of reports published or in preparation this year, describing the structure and oil prospects in many new and undeveloped areas, especially in the Western States, in the Southwest, and in the Midcontinent region, will be found in the record of the geologic work carried on in the several states. Even with all the funds which, with justice to other mineral interests, could be devoted to investigations of oil and gas, it has not been found possible to extend these researches at all in proportion to the increase in public demand for information both as to old and to new fields. A recent editorial in the *Standard Oil Bulletin* states: "Time was when oil operators were strongly inclined to give little or no heed to the opinions of geologists, but that time is past." The value of the studies of geologic structure in the search for oil is not only thus recognized by the great oil companies, but most of these corporations are now recruiting corps of geologists, if they had not already had trained geologists in their employ. Naturally, the information thus acquired by these corporations for their guidance in leasing lands and in locating exploratory drill holes is not available to the public—a fact which makes more pressing the need of the landowner and of the small independent driller for all the information which the federal or state surveys can give.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for February; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "The Fairy Lily," W. N. Clute; "Our Most Fragrant Flowers; The Monterey Cypress," W. A. Squires.

American Forestry, for February; *Washington, D. C.; $3.00 per year, 25 cents a copy:* "The White Pine Blister Disease," Dr. Perley Spaulding, S. B. Detwiler, C. R. Pettis, and Dr. Haven Metcalf; "Losses Caused by Imported Tree and Plant Pests," C. L. Marlatt; "The Locusts," S. B. Detwiler.

American Journal of Botany, for February; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "Fifteen-and Sixteen-Chromosome Oenothera Mutants," Anne M. Lutz; "The Influence of Temperature on the Growth of Endothia Parasitica," Neil E. Stevens.

American Mathematical Monthly, for February; *5548 Kenwood Ave., Chicago; $3.00 per year:* "On the Origin of Certain Typical Problems," David Eugene Smith; "An Inversion of the Complete Quadrilateral," J. W. Clawson; "A Problem in Probability," C. S. Jackson; "A Simple Geometrical Paradox," J. L. Coolidge.

American Naturalist, for February; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "The Selection Problem," Dr. Raymond Pearl; "Mendelian Factor Differences *versus* Reaction System Contrasts in Heredity, II," Dr. T. H. Goodspeed and R. H. Clausen.

Geographic Review for February; *New York City; $5.00 per year, 50 cents a copy:* "A Proposed Aerial Expedition for the Exploration of the Unknown Interior of New Guinea" (2 maps, 11 photos), Eric Mjoberg; "The Development of the Appreciation of Mountain Scenery in Modern Times" (4 photos), Walter Woodburn Hyde; "A Map of the Vegetation of the United States," Forrest Shreve; "The Influence of Weather on Street-Car Traffic in Duluth," Eugene Van Cleef; "Is the Atlantic Coast Sinking?" Douglas W. Johnson.

Journal of Geography, for March; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "The Development and Present Organization of Elementary School Geography in the United States," Olive J. Thomas; "The Caravan Trade of the Sahara," Genivera Loft; "Some Movements of State Centers of Population and Their Significance," Roland M. Harper.

Literary Digest, for March 3; *New York City:* "Food Riots in the United States;" "Uncensored News from Germany;" "Does the Melting Pot Melt?" "Some Needed Inventions;" "Woman's New Jobs."

National Geographic Magazine, for January; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "The Valley of Ten Thousand Smokes, Katmai District of Alaska" (52 illustrations), Robert F. Griggs; "On Big Trees Saved" (10 illustrations); "A Game Country Without Rival in America" (16 illustrations), Stephen R. Crafts.

Nature Study Review, for February; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Spontaneity in Nature Study," S. C. Schmucker; "Standardizing Nature Study," F. L. Holtz; "Plan for the Study of the Elm Tree in Primary Grades, A," Susan B. Sipe; "Red-headed Woodpecker," Mary Loesch; "February Nature Study," Anna Botsford Comstock.

Photo-Era, for March; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Getting Meaning in a Picture, Part I," C. H. Claudy; "Just Kids," A. E. Churchill; "Burson—Press Photographer," Michael Gross; "Instantaneous Photography with Wet-Plates," William Herbert Rollins; "The Complete Outfit," L. D. Rowell; "Studio-Coupons—What Shall We Do with Them?" Jessie Robinson Bisbee; "How to Obtain Soft, Rich-Toned Negatives," J. K., in Photo. Rundschau; "The Use of Chiffon in Enlarging," David Ireland.

Physical Review, for February; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "Polarization at the Cathode in a Highly Ionized Gas," C. A. Skinner; "The Influence of Water of Crystallization upon the Fluorescence and Absorption Spectra of Uranyl Nitrate," Edward L. Nichols and Ernest Merritt; "The Mica X-Ray Spectrometer—A Reply to Mr. Siegbahn," W. S. Gorton; "The Tungsten Arc Under Pressure," George P. Luckey; "Note on the Elastic Constants of Antimony and Tellurium

Wires," P. W. Bridgman; "The Actinium-Uranium Ratio in Colorado Carnotite," Karl H. Fussler; "The Optical Properties of an Isolated Crystal of Selenium," Charles H. Skinner; "Measurements in Frictional Electricity," N. R. French; "The Mass of the Electric Carrier in Copper, Silver and Aluminium," Richard C. Tolman and T. Dale Stewart.

Popular Astronomy, for March; *Northfield, Minn.; $3.50 per year:* "The Snow Peaks of Theophilus," William H. Pickering; "Questions Suggested by the Sun's Motion," W. E. Glanville; "The Tulse Hill Observatory Diaries," Sarah Frances Whiting; "The American Meteor Society in 1916," Charles P. Olivier; "The Impact Origin of the Moon's Craters" (with Plates VI and VII), Donald Putnam Beard; "The Fraunhofer G Group and the Hydrocarbon Band" (with Plate VIII), Frances Lowater.

Popular Science Monthly, for March; *New York City; $1.50 per year, 15 cents a copy:* "Modern Conveniences on the Farm;" "What the First Telegram Said;" "The Native Homes of Orchids and Dwarfed Pines;" "Developing a Long Photographic Film in One Piece;" "Increasing the Frequency in Radiotelegraphy;" "A New Mercury Interrupter for Spark Coils."

Review of Reviews, for March; *New York City; $3.00 per year, 25 cents a copy:* "Canada in War Time;" "The Situation in Russia;" "Cromer's Rule in Egypt;" "Our New Caribbean Islands;" "Raising and Selling Beef Cattle in America."

School Review, for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Wyoming Plan of Military Training for the Schools," Captain E. Z. Steever, U.S.A.; "Preparing While We Wait," Captain H. L. Durborow; "Military Drill in High Schools," Leonard P. Ayres; "Military Training in the High School," D. C. Bliss; "Massachusetts Commission on Military Education;" "Brief Summaries of Principal Military Systems, by the Massachusetts Commission on Military Training;" "Standardized Tests and the Improvement of Teaching in First-Year Algebra, II," H. O. Rugg and J. R. Clark.

School World, for February; *Macmillan & Company, London, Eng.; 7s 6d per year:* "An Educated Nation," Gilbert Murray; "Education and Business," W. L. Hichens; "Out-of-School Jurisdiction of Headmasters," C. W. Kaye; "Science for the Rank and File," R. A. Gregory.

WHEAT AND FLOUR REFERENCES.

PREPARED BY W. M. GREGORY,
Normal School, Cleveland, Ohio.

The following list of references upon wheat and flour has been prepared for the use and help of the students and teachers of commercial and industrial geography, agriculture and domestic science. The list includes sources that ought to be used when these subjects are well taught, and the star (*) indicates that the book has been used with junior high school students.

1. Adams. Essentials of Com. Geog.
2. *Allen. Industrial Studies, U. S.—Chap. IX.
3. American Commerce, One Hundred Years of. Vol. 1, p. 266–273.
4. *Bengtson and Griffith. The Wheat Industry.
5. *Blaich. Three Industrial Nations. p. 186.
6. Bogart. Economic History. pp. 239, 245, 270.
7. Brigham. Com.Geog. Chap.1.
8. Buffum and Deaver. Sixty Lessons in Agriculture.
9. *Carpenter. How World is Fed. Chapts. 2, 3, 4, and 5.
10. Casson. Romance of Reaper.
11. Century Magazine. Vol. 76. p. 736. Future Wheat Supply of U. S.
12. Chamberlain. North America. p. 248.
13. *Chase and Clow. Stories of Industries. Vol. 2.
14. Commercial America. Dec., 1905. p. 8, American Bread.
15. Crookes, Wheat Problem.
16. Curtiss, Wheat Culture.
17. De Candolle, Origins of Cultivated Plants, Wheat.

18. Dodlinger. The Book of Wheat.
19. Edgar. A Modern Wheat Farm. Scribner's Mag. Vol. 22. p. 531.
20. Edgar. The Story of a Grain of Wheat.
21. Farnham. Wheat Culture. Journal of Geog. May, 1906. p. 213.
22. Freeman and Chandler. World's Com. Products.
23. Jefferson. Commercial Values.
24. *Keller and Bishop. Com. and Indus. Geog. p. 136.
25. Laut. Harvesting the Wheat. Outing. Vol. 53. p. 1–16.
26. *Monroe and Buckbee. Our Country and Its People. Chap. V.
27. *Morris. Indus. and Com. Geography. p. 63.
28. Mumford. Dakota, the Land of Wheat. Harper's Weekly. Vol. 52. p. 24.
29. New York State Course of Study. Outline for Study of Wheat. 1910.
30. *Pillsbury Company. A Kernel's Story.
31. Review of Reviews. Vol. XL. p. 324. Supply and Consumption of Wheat.
32. Robinson. Com. Geog. p. 88, 440.
33. *Rocheleau. Geog. of Commerce and Industry. p. 47.
34. *Rocheleau. Products of the Soil. p. 150.
35. *Rusmisel. Ind. and Com. Geog. Chap. VIII.
36. *Russell–Miller Milling Co. Manufacturer of Wheat Flour.
37. Rutter. Wheat Growing in Canada, United States and Argentina.
38. Salisbury, et al. Elements of Geog. pp. 205, 543, 545.
39. *Sanford. History of Agriculture in United States.
40. Scientific American. Sup. 64. p. 394. Wheat from Mill and Market.
41. Scientific American. Vol. 96. p. 450. Our Wheat Crop.
42. *Scientific American. Dec. 11, 1909. Pictures.
43. *Scientific American. Feb. 18, 1911. Pictures.
44. *Scientific American. Dec. 18, 1909. Diagrams of Wheat Crops.
45. Scientific American. Vol. 96. Wheat Crop. Diagrams.
46. Scribner's Mag. Jan. 187. A Great Wheat Farm.
47. *Smith. Commerce and Industry. Chap. 1.
48. Smith. Indus. and Com. Geog. Chap. 111.
49. Smith. Making of America. Vol. 1. p. 147. The Mighty River of Wheat.
50. Smith. Wheat Fields and Markets of the World.
51. Todd. Northwest Mag. Apr., 1900. How Grain is Handled in Minnesota.
52. Redway. Com. Geog.
53. Trotter. Geog. of Commerce. p. 91.
54. *Trotter. New Geog. p. 66.
55. Upham. Introd. to Agri. p. 137.
56. U. S. Census. Vol. 8. p. 384. Flour and Grist Mill Products.
57. U. S. Census. Vol. 10. p. 407. Flour. Diagrams.
58. U. S. Census. Vol. 5. p. 585. Wheat Crop. Diagrams.
59. *Washburn-Crosby Co. Wheat and Flour Primer.
60. Wilkinson. Practical Agri. Chap. 15.
61. *World's Work. Vol. 9. p. 5459, 5467. Pictures.
62. World's Work. Vol.7. p.4232.

*Suitable for children.

DOES ALTRUISTIC MEAN "ALL TRUE"?

Here is a rather interesting paragraph from the paper of an applicant for position of teacher of high school mathematics. The supposition is that he pronounced the word "*all-true*-istic," and hence his deduction that the word means "all true."

"The second aim, and the most important is the altruistic development obtained from the study of mathematics. Expressions must be accurate. No slight deviation from the truth can be made. An equation must tell the truth and all the truth. If $x^2 = 16$, it isn't the whole truth if $x =$ only 4."

BOOKS RECEIVED.

Elementary Algebra, by Elmer A. Lyman, Normal School, Ypsilanti, Michigan, and Albertus Darnell, Central High School, Detroit, Michigan. Pages vii—503. 13x19 cm. Cloth. 1917. American Book Co., Chicago.

Animal Micrology, by Michael F. Guyer, University of Wisconsin. Pages xi—289. 16x22.5 cm. Cloth. 1917. $2.00 net. Postage extra. Wt. 1 lb. 10 oz. University of Chicago Press.

Handbook of Engineering Mechanics, by Walter Weynee and William Spraragen. Pages x—220. 10.5x17.5 cm. Leather, flexible. 1916. $2.00 net. D. Van Nostrand & Co., New York.

Microbiology, edited by Charles E. Marshall, Massachusetts Agricultural College. Pages xxiv—900. 14x20 cm. Cloth. 1917. $3.00 net. P. Blakiston's Son & Co., Philadelphia.

Practical Physics Manual, by W. R. Ahrens, Englewood High School, Chicago, T. L. Harley, Hyde Park High School, Chicago, E. E. Burns, Medill High School, Chicago. Pages xviii—354. 14.5x21 cm. Cloth. 1917. $1.25 net. P. Blakiston's Son & Co., Philadelphia.

Household Accounting and Economics, by William A. Shaeffer, West Division High School, Milwaukee. Pages xi—161. 13x19.5 cm. Cloth. 1917. $.65. The Macmillan Company, New York City.

BOOK REVIEWS.

Practical Physics Manual, by W. R. Ahrens, Englewood High School, T. L. Harley, Hyde Park High School, E. E. Burns, Medill High School; all of Chicago. Pages xviii +354. 13.3x19.4 cm. 1917. P. Blakiston's Son and Com., Philadelphia.

This new physics manual emphasizes "the study of the physics of daily life," being "prepared from the point of view of the new movement in the teaching of physics," to quote from the author's preface. It is larger than the average high school physics manual, containing 153 experiments and an appendix of 31 tables of physical constants. The experimental directions are well illustrated by a uniformly well-drawn series of 132 figures; these are largely original and are accurate and up to date. Well arranged tabular forms are inserted freely, the type is of good size. the press work excellent. Each experiment begins upon a new page. Taken altogether, the attractive appearance of this book will appeal to both teachers and pupils.

The authors have shown good pedagogical insight by endeavoring to make the pupil feel at the beginning of each experiment that a worthwhile problem requiring solution is before him. The attempt to bring about this desirable condition is made in the opening sentence of the experiment, which is phrased in the form of a question. Thus the experiment on the vernier caliper begins "How can accurate measurements, say on the tenth of a millimeter, be made?" One on thermoelectric generators begins; "Where are thermoelectric couples employed to great advantage in the commercial world?"

A wide range of experiments is included, so that it is possible to form three distinct tables of contents; one illustrating the principles of physics usually considered in a high school course, one especially adapted to a *household physics* course, and one for a *technical* or *electrical* course. Included in the latter are sixteen experiments upon *alternating currents.*

The experiments throughout are characterized by a simplicity and a directness that should make this manual conspicuously successful in the laboratory. Its preparation reflects the long and successful experience of the authors in the teaching of high school laboratory physics.

W. E. T.

READY IN APRIL

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Ginn and Company

Boston New York Chicago London
Atlanta Dallas Columbus San Francisco

Laboratory Manual for General Science, by Lewis Elhuff, George Westinghouse High School, Pittsburgh, Pa. Pages vi-90. Cloth. D. C. Heath & Company, Boston.

This little book was written primarily to accompany the author's general science text. It is exceedingly well written, and the exercises, of which there are 112, have been selected with great care. They are of such a nature as to bring out prominently the more important points discussed in the author's text. C. H. S.

Food Study—A Textbook in Home Economics for High Schools, by Mabel T. Wellman, Indiana University. Pages xxi—324. 13.5x19cm. Cloth. 1917. $1.00. Little, Brown & Co., Boston.

A splendid work which has been written for the purpose of giving specific directions in such a manner as to assist the user in her work in the study of foods. It is a book which a person with average intelligence and knowledge of foods could study and master herself without the assistance of a teacher. It is not, however, intended to supercede the teacher. The inductive method of instruction is followed throughout the text. The book is filled from cover to cover with helpful suggestions as to the way in which home economics should be taught. There are 57 chapters in the work. There are many half-tones and diagrams scattered throughout the text. Each chapter has at the close a bibliography, together with a list of questions that have been brought out by the discussion in the chapter. There are several tables in the appendix of a helpful nature. The paper is not highly calendared, thus making it a text easy to read without the intensified reflection of light, when the pages are held at a certain angle. It is well written, the diction is without fault, and the volume deserves an extensive sale. C. H. S.

Laboratory Course of Practical Electricity, by Maurice J. Archibald, Wendell Phillips High School, Chicago, Ill. Pages ix-222. 18.5x24.5 cm. Paper. 1916. The Macmillan Company, New York City.

This is a manual which can be used with any textbook on electricity. The exercises have been selected and prepared by the author after careful experimentation with them in his classes. The plan of the book is of such a nature that the report of the exercises may be made in the blank spaces in connection with each experiment. This saves much time on the part of the pupil in reporting his work. It likewise economizes much of the instructor's time in reviewing the report of the pupil. The drawings are practically all new, and are very well executed. They are numbered to correspond with the exercises, and are placed altogether in the back of manual. They give the pupil a plan by which the apparatus should be connected. The book is very practical and fully up-to-date. It deserves and doubtless will have an extensive sale. C. H. S.

An Introduction to Astronomy, by Forest Ray Moulton, University of Chicago. Pages xxii-577. 14x20 cm. Cloth. 1916. $2.25. The Macmillan Company, New York.

Without question this is one of the very best texts on astronomy that have ever been published. The author is a person of world-wide reputation, and his name being attached to this work is an assurance that the matter contained therein is authentic, well written, splendidly presented, and that it covers the ground in a manner which would be difficult for anyone to excel. The work is not intended for the purpose of making astronomers out of the readers. While it may have been written primarily for a textbook, it is one which can be recommended to the lay reader as well, and all people who wish to keep abreast of the times in this science should have a copy in their library. The main discoveries in astronomy during the last decade have been the cause of enlargement of the work at many points in the last chapter.

Nothing but words of commendation can be given in reference to the work. The major paragraphs, of which there are 340, begin with bold-faced type. The words in this type really are the subject of the matter discussed in that paragraph. The mechanical work is superior. The world of science is indebted to the author for this splendid treatise.

C. H. S.

A Catalogue of Scientific Instruments, L. E. Knott Apparatus Company, Boston. 507 pages. 21x26.5 cm. Cloth. 1916. Published by L. E. Knott Apparatus Company, 79 Amherst St., Boston, Mass.

Many firms do not seem to appreciate the value of a thoroughly up-to-date catalogue of the apparatus and material which they manufacture and sell. This criticism cannot be made, however, with reference to this firm, because they have issued a catalogue which for comprehensiveness, cleverness in its design, exceedingly high quality of cuts, and splendid character of type used, is second to no other catalogue of a similar nature published. There are literally thousands of cuts in the catalogue. Apparently, material may be ordered direct by number without elaborate description, and the buyer can rest assured that he will receive the type of apparatus ordered. There are presented in the catalogue a great number of new pieces of apparatus recently put on the market. There is apparently apparatus for all phases of secondary school and college work, especially in the sciences of physics, chemistry, and biology. There is a very complete index of ten pages, three columns to the page, in the back. This enables one to locate a particular kind of apparatus without any difficulty. The descriptions of apparatus are clear, concise, and to the point. The prices are given in almost every instance. It is a catalogue which all instructors in biology, chemistry, and physics and general chemistry should possess. C. H. S.

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NEW YORK, N.Y. PITTSBURGH, PA. OTTAWA, CANADA

Geography of the Upper Illinois Valley—History of Development, by Carl O. Sauer. 208 pages. 18x25.5 cm. Cloth. Illinois State Geological Survey, Springfield, Ill.

This is a splendid report of the recent geological survey of the Upper Illinois Valley. It is written in a language that will be clearly understood by the ordinary lay reader, as it is presented in a very nontechnical manner and is largely intended for the farmers who live in this particular valley. Yet at the same time it would be a splendid textbook to place in the hands of pupils and teachers in the great state of Illinois, as it is a faithful translation of the record of this part of the earth's surface as it is shown by the rocks and soils of the state. The book is illustrated by 69 half-tones and maps, together with a splendid geological map of the valley, and with a panoramic view of the Illinois valley at Starved Rock. It is a book that every teacher of geography and physiography, as well as geology, in the state of Illinois, should possess. The book is well made, and the author of it deserves much credit for presenting such an admirable volume. C. H. S.

The Principles of Health Control, by Francis M. Walters, Professor of Physiology and Hygiene, State Normal School, Warrensburg, Mo. 13x19 cm. Cloth. Illustrated. $1.20. D. C. Heath & Company, Boston.

The purpose of the book seems to be to present to the student in as clear and simple a manner as possible the fundamental laws of health; first in the individual, then in the community. The watchword is "Control."

The introduction (Chapter I) discusses the value of health in its largest sense—the basis of efficiency, happiness, personal attractiveness, length of life, and racial vigor.

Chapter II is a brief review of the physiological processes and their relation to cells. It is summarized as follows: "Since we can determine what substances shall enter the body, govern to some extent the efficiency

of the vital organs, determine our adjustment to environment, and regulate the expenditure of our energy, we can control * * * our health."

Chapter III takes up health variations in the same person and health differences among people, and the direct and indirect causes of disease. There is a blank at the end for self-examination.

Twelve chapters then follow with detailed instructions in "Control," beginning with exercise and posture, and closing with the relation of mental and emotional states to the physical condition, and the principles of nerve conservation. He leads up well to the topic or problem of prolonging the period of mental efficiency.

The two chapters on "Germ Fighting" treat in a very suggestive way the defensive and the offensive methods. In no book of a similar character is the process of preparing an antitoxin better treated. The offensive treatment concludes with several paragraphs under "Health Work." The following version of the Golden Rule is given: "As we would that others protect us from their germs, so should we protect them from our germs."

Review exercises and several paragraphs on "Health Work" follow each chapter. The latter are especially good.

The modern trend of the book is shown in several chapters, but especially so in the last on the larger control through social readjustment. Here eugenics is given its proper attention in a very few words.

This is a book that deserves the consideration of school authorities and people outside of schools. Its author has worked it out to meet the needs in a normal school, but it could equally well adapt itself to the high school, where the regular course in physiology should precede or accompany the course in hygiene.

L. LENORE CONOVER.

Laboratory and Field Work in Zoology, by Robert W. Hegner, University of Michigan. Cloth. 73 pages. 40 cents. The MacMillan Company.

Laboratory Problems in Civic Biology, by George William Hunter, Dewitt Clinton High School, N. Y. City. Cloth. Illustrated, 283 pages. American Book Company.

A Laboratory Manual for General Science, by Caldwell, Eikenberry and Pieper, School of Education, University of Chicago. 134 pages. Size, 20x26cm. Cloth. Price 50 cents. Ginn and Company.

Reproduction and Sex Hygiene, by Walter Holtes Eddy, High School of Commerce, New York City. Cloth, loose-leaf. 20x26cm. 82 pages, illustrated. Ginn and Company.

One Hundred Exercises in Agriculture. Gehrs and James, State Normal, Warrensburg, Missouri, and University of Wisconsin. A loose-leaf manual, illustrated with figures and tables. Paper cover. The MacMillan Company. 20x24 cm.

Laboratory manuals have their place in schools and if used rightly they may do good service. To the overworked high school teacher with overlarge classes or to those who are delegated to teach a laboratory science by those in authority for which there is insufficient preparation the manual comes as a blessing. Also in the newer laboratory sciences as household science or agriculture, the manual serves to point the way and aid to a more logical development of the subject.

But there are dangers connected with the use of manuals. There may be a too slavish adherence to the text, thus killing originality and adaptation to the environment of the school. Then, too, the manual may serve to fix the course of study of any given subject too rigidly. The course of study should be flexible, and anything that may tend to fix a certain routine to be followed should be shunned. Better to have

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some vagueness but with some incentive to adaptation left, than a fixed and lifeless course.

Laboratory and Field Work in Zoology. It is quite evident that this book was prepared to aid in introducing the author's textbook in zoology It is planned in the conventional way and will be helpful to teachers who need such help, but another book, like Hunter's Civic Biology, should be used with it as an antidote, for it is severely morphological in the character of its directions and questions. The general make-up of the book is all that could be desired.

Laboratory Problems in Civic Biology. There are 249 "problems" proposed for laboratory study and solution. The range of these problems is very great, as the title sugg sts and those acquainted with the author's methods will surmise. There is also a mass of details in the form of tables, as for example one on pages 270 and 271 on deaths by preventable diseases. Numerous references are given at the end of each chapter.

The idea of the book is good, but we think that the author's zeal has led him to overload the work. Ninth and tenth grade pupils cannot assimilate such a mass and variety of information without danger of "going stale" or of bewilderment and failure to get anywhere. By the author's method of leading the thinking of the pupils in a sort of concert plan of study it is true one may easily cover a great deal of ground, but we think this a bad method, as bad in one way as the "memory method" is in another. Better be content with fewer problems and allow each pupil a chance to develop according to his own capabilities and individuality. Concert methods tend to kill ambition and initiative, and no advantage in speed or ease of control of large classes can justify it.

As a source book of ideas and material for the teacher's plans it is an undoubted success and it should be in the hands of every teacher of biology.

A Laboratory Manual for General Science. This is a subject that stands in need of laboratory manuals. The lack of coherent plan and carefully worked-out problems are undoubtedly chiefly responsible for the lack of success of which we hear. This manual has been carefully prepared with ample trial in class during its formative stage. We note numerous questions which must make the pupil try to think for himself. For those who think the emphasis should be laid on the biological side of the work we can heartily commend the book.

Reproduction and Sex Hygiene. This is an attempt to make the study of biology serve the purpose of a course in eugenics. We have had civic biology and we might have agricultural biology. There is danger in these courses—their narrowness. Why not have biology without a descriptive adjective and adopt the course to the needs of the situation? In the case of the book noted above we think the field too narrow. The influence of the study would be greater if broad enough to take in the social and ecological side of man and animals and plants. There are questions of parasitism, secluded life, influence of environment, food and habits, that are of great importance. The author has a very carefully planned series of studies and we do not wish to say anything against their importance and value, but we believe that a broader approach to the subject of reproduction and sex would tend to remove any danger there may be of morbid curiosity and greatly increase the value of the work and its influence on the mind of the pupil.

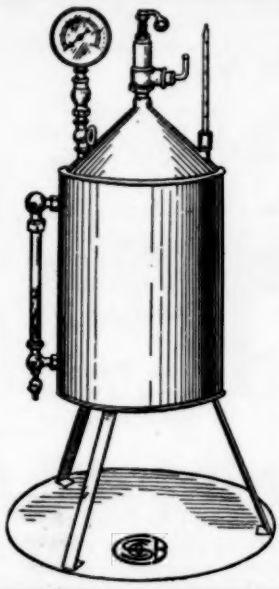
One Hundred Exercises in Agriculture. There is need of good manuals in this subject, for we have an idea that there is a lot of motion work under the name of agriculture that gets nowhere. This appears to be one of the best manuals for an elementary course in agriculture that we have seen. There are illustrations where they will be helpful and numerous tables for recording notes and observations. An excellent feature of the exercises are the lists of questions appended to drive home the lesson meant to be taught by the exercise.

We note, however, the omission of some important topics. There are no exercises on breeding. The principles of plant breeding, of variation and selection, of heredity and Mendel's Law are rather easily worked out in practical exercises and they are of fundamental importance. There are also no exercises on plant and animal enemies, or diseases, and their prevention, certainly an important part of the education of a successful farmer.

With these exceptions we find the book exceedingly well planned. The section on farm management is especially good. Farming is a business proposition. We would have better farming if this were more fully realized. W. W.

Human Physiology, by Percy G. Stiles, Harvard University and Massachusetts Institute of Technology. 405 pages. Illustrated. Cloth, $1.50 net. 1916. W. B. Saunders Company.

According to the author this book is written for high schools and colleges. It can be used in high schools only in the upper grades after considerable training in science. The style of the book is fascinating, so much so that the reviewer found it difficult to stop reading. Whether it will prove as valuable for class work is not so certain—it depends upon what is expected of the textbook. It is not a drill book and would not be suitable for crams. The information seems to be up to date and satisfying. One will find chapters on nutrition and diet that include a discussion of "vitamines," "polished rice" and other much-talked-of matters of present interest. We recommend the book for the libraries of all teachers of high school physiology and as worthy of careful consideration for use as a textbook within its range.



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Outlines of Physiology, by Edward G. Jones and Allen H. Bunce, both of Emory University, Atlanta, Ga. Cloth. 373 pages and 111 illustrations. 1916. $1.50 net. P. Blakiston's Son and Co.

This book was written with an entirely different viewpoint than the preceding and is consequently very different in its style and manner of treatment of the subject matter. It is preeminently a study book and a reference book. The matter is in compact form and there is free use of leaded type and italics. Its serviceableness has been proved by the fact that it has been through three editions.

Textbook of Anatomy and Physiology, by Elizabeth R. Bundy, Woman's Hospital, Philadelphia. 410 pages with 243 illustrations, 46 of which are in color. Cloth. Price $1.75 net. 1916. P. Blakiston's Son and Co.

This is likewise a fourth edition and revision of a book that has received mention in these columns with previous editions. The book has been revised in various details to make it more serviceable and to bring the matter up to date. It is written primarily for training classes in nurse schools. But the book is so well written that it certainly has a much wider use than this. We can recommend it heartily to those who wish both anatomy and physiology in a compact form without great details.

How to Know the Mosses, by Elizabeth M. Dunham, member of the Sullivant Moss Society. 287 pages. 13x19 cm. Illustrated. Cloth. $1.25 net. Houghton, Mifflin Company.

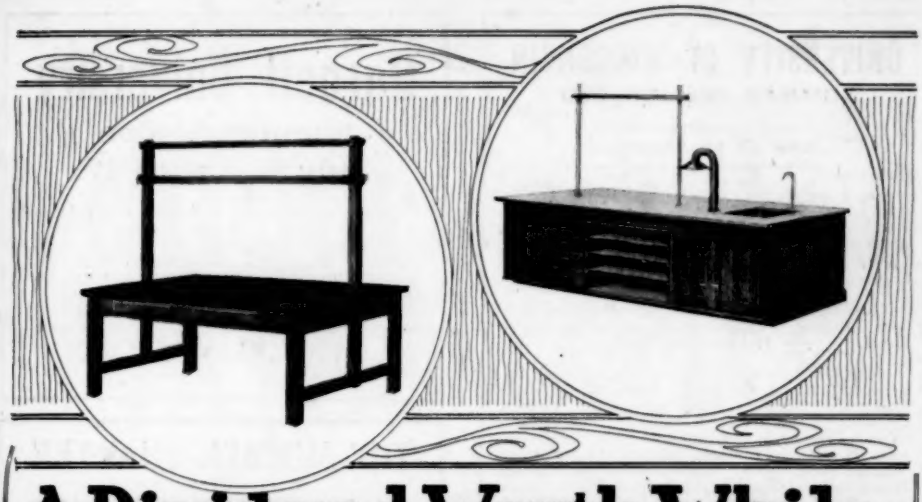
This is a popular guide to the mosses of the northeastern United States and contains keys to 80 genera and short descriptions of over 150 species, with special reference to distinguishing characters that may be observed *without* a lens.

We have had Grant's *Key to the Mosses with* the aid of a hand lens, but this is the first attempt to classify mosses without even the hand lens as an aid. The keys work, for we have tried them. One of the most important aids is the illustrations of terms, there being four full pages of such illustrations. In all there are thirty-two pages of explanations before a key is attempted. Then there follow two keys—one to genera by means of the leaf, the second by means of capsules. There are numerous short keys, and the descriptive matter is well chosen and not too profuse. We can very highly recommend this book to secondary school teachers in need of such a help. It is a fine book for the summer vacation. W. W.

Dairy Farming, by C. H. Eckles, University of Missouri, and G. F. Warren, Cornell University. 309 pages. Illustrated. 13x19 cm. Cloth. $1.10. The MacMillan Company.

This is one of the books that delight the practical teacher. Too often the people who write textbooks have not the faintest conception how the subject matter ought to be presented and often but little knowledge of just what should go into the proposed book.

This book is well illustrated where illustrations are needed. The paragraphs are short and to the point. The subject matter is well organized, and there are numerous aids for the student and teacher in the way of tables of data, suggestive questions, laboratory exercises, etc. Everything that should go into a book on dairy farming seems to have been thought of. We might mention a few topics that might have been overlooked; they are, "Conditions Affecting the Development of Dairying," such as climate, topography, etc.; "Systems of Farming on Dairy Farms;" "Methods of Renting Dairy Farms;" "Cost of Production," and "Marketing;" "Other Important Factors for Success in Dairy Farming." W. W



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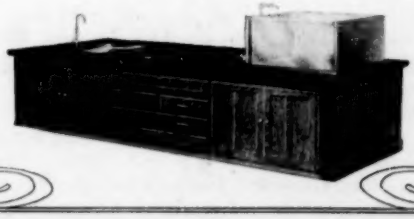
K  K

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A Textbook of Human Physiology, by Albert P. Brubaker, Jefferson Medical College. Cloth. 775 pages with 359 illustrations, 1 colored. 1916. Price $3.00 net. P. Blakiston's Son and Co.

This is the fifth revised edition of this popular textbook. As will be noted above it contains a much more extensive treatment of the subject of physiology than any of the books just mentioned. As the book has been reviewed as former editions came out it is not necessary to go into details now. Suffice it to say that the book is written from the medical point of view for medical students and practitioners. It is comprehensive and conservative in its method of developing the subject matter—a straight forward statement of the known facts with little discussion or entire omission of unsettled questions. W. W.

Plant Anatomy, by William Chase Stevens, University of Kansas. Third edition, revised and enlarged. 399 pages. 155 figures. 15x22 cm. $2.50. P. Blakiston's Son and Co.

In the second edition a chapter on reproduction was added. In this edition additions have been made on the phylogeny of the vascular bundle and various improvements to the chapters on "reagents and processes" and "microchemistry of plant products."

The book has been carefully worked out and should be useful in the college classroom. For the secondary school botany teacher it should be valuable as a reference book, because it is up to date, accurate and concise in its expositions of plant tissues. The last five chapters on the preparation of sections, the microscope, reagents and processes, microchemistry of plant products, and detection of adulterations in foods and drugs should be especially valuable for reference. W. W.